VIRGINIA DEPARTMENT OF MINES, MINERALS & ENERGY

DIVISION OF MINES

HOISTING ENGINEERING STUDY GUIDE

CERTIFICATION STUDY GUIDE

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Commonwealth of Virginia
Department of Mines, Minerals, and Energy
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DEPARTMENT OF MINES MINERALS AND ENERGY
DIVISION OF MINES

Disclaimer

Article 3 of the **Coal Mine Safety Laws of Virginia** establishes requirements for certification of coal mine workers. The certification requirements are included in §45.1-161.24 through §45.1-161.41 in which the Board of Coal Mining Examiners is established for the purpose of administering the certification program. The Board has promulgated certification regulations 4 VAC 25-20, which set the minimum standards and procedures required for Virginia coal miner examinations and certifications.

The Virginia Department of Mines Minerals and Energy, Division of Mines developed this study guide to better train coal miners throughout the mining industry. The study guide material should be used to assist with the knowledge necessary for coal mining certifications. The material is not all-inclusive and should be used only as an aide in obtaining knowledge of the mining practices, conditions, laws, and regulations. This material is based upon the Coal Mining Safety Laws of Virginia, Safety and Health Regulations for Coal Mines in Virginia, Title 30 Code of Federal Regulations (30 CFR), State and Federal Program Policy Manuals and other available publications. Nothing herein should be construed as recommending any manufacturer's products.

The study guide and materials are available at the Department of Mines, Minerals and Energy. Any questions concerning the study guide should be addressed to the Regulatory Boards Administrator at the Big Stone Gap Office.

Hoisting Engineering
Certification Study Guide

INTRODUCTION

The purpose of the Hoisting Engineering Certification Study Guide is to assist a qualified applicant in obtaining the Hoisting Engineering certification. The Board of Coal Mining Examiners (BCME) may require certification of persons who work in coal mines and persons whose duties and responsibilities in relation to coal mining require competency, skill or knowledge in order to perform consistently with the health and safety of persons and property.

The purpose of the hoisting engineering study guide is to assist an applicant who possesses two-years practical mining experience and one-year hoisting experience under the direction of a certified hoisting engineer or appropriately related work experience

The hoisting engineering certification authorizes the holder to perform:

- Hoisting operations at shafts, slope and surface inclines
- Pre-operations and other required safety checks of hoisting equipment
- Record results of hoisting equipment examinations
- Duties of an automatic elevator operator after completing the on-site demonstration required by Section 2.20 of the BCME regulations

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HOISTING ENGINEERING
STUDY GUIDE
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Unit 1

Coal Mine Safety Laws Of Virginia

§ 45.1-161.153. Hoisting equipment.

A. All hoists used for handling men shall be equipped with overspeed, overwind, and automatic stop controls.

B. All suspended work decks and platforms (i) shall operate automatically, (ii) shall be equipped with guardrails capable of protecting men and materials from accidental overturning, and (iii) shall be equipped with safety belts and such other protective devices as the Chief shall require by regulation.

C. Any platform or work deck used for transporting miners or materials shall be equipped with leveling indicators and such conveyance shall be maintained and operated in a reasonably level position at all times.

D. Slope, shaft, or surface incline hoists shall be equipped with brakes capable of stopping and holding the fully loaded unbalanced cage or trip at any point in the shaft or slope or on the incline.

E. An accurate and reliable indicator showing the position of the cage or trip shall be placed so as to be in clear view of the hoisting engineer, unless the position of the car or trip is clearly visible to the hoisting engineer or other person operating the equipment at all times.

F. Any conveyance used to haul miners or materials within a shaft or slope (i) shall be designed to prevent materials from falling back into the shaft or slope and (ii) shall be equipped with a retaining edge of not less than six inches to prevent objects from falling into the shaft or slope.

§ 45.1-161.154. Hoisting ropes.

A. Hoisting ropes on all cages or trips shall be adequate in size to handle the load and have a proper factor of safety. Ropes used to hoist or lower coal and other materials shall have a factor of safety of not less than five to one; ropes used to hoist or lower miners shall have a factor of safety of not less than ten to one.

B. he hoisting rope shall have at least three full turns on the drum when extended to its maximum working length. The rope shall make at least one full turn on the drum shaft or around the spoke of the drum, in case of a free drum, and be fastened securely by means of clamps.

C. The hoisting rope shall be fastened to its load by a spelter-filled socket or by a thimble and adequate number of clamps properly spaced and installed.

D. Any cage, man-car, or trip used for hoisting or lowering men with a single rope shall be provided with two bridle chains or wire ropes connected securely to the rope at least three feet above the socket or thimble and to the crosspiece of the cage or to the man-car or trip.

E. When equipment or supplies are being hoisted or lowered in the slope, safety chains or wire ropes shall be provided and connected securely to the hoist rope. In addition, visible or audible warning devices shall be installed in the slope where they may be seen or heard by persons approaching the slope track entry from any access.

§ 45.1-161.155. Hoisting cages.

A. Cages used for hoisting miners shall be of substantial construction and shall have (i) adequate steel bonnets, with enclosed sides; (ii) gates, safety chains, or bars across the ends of the cage when men are being hoisted or lowered; and (iii) sufficient handholds or chains for all men on the cage to maintain their balance. A locking device to prevent tilting of the cage shall be used on all self-dumping cages when miners are transported thereon.

B. The floor of the cage shall be constructed so that it will be adequate to carry the load and so that it will be impossible for a miner's foot or body to enter any opening in the bottom of the cage.

C. Cages used for hoisting miners shall be equipped with safety catches that act quickly and effectively in case of an emergency. The provisions of this subsection shall not apply to capsules or buckets used for emergency escape or used during slope or shaft sinking.

§ 45.1-161.156. Slope and shaft conditions.

A. All shafts shall be equipped with safety gates at the top and at each landing. Safety gates shall be kept closed except when the cage is being loaded or unloaded.

B. Positive-acting stopblocks or derails shall be installed near the top and at intermediate landings of slopes and surface inclines and at the approaches to all shaft landings.

C. Positive-acting stopblocks or derails shall be installed on the haulage track in the slope near the top of the slope. The stopblocks or derails shall be in a position to hold or stop any load, including heavy mining equipment, to be lowered into the mine until such time as the equipment is to be lowered into the mine by the hoist.

D. At the bottom of each hoisting shaft and at intermediate landings, a runaround shall be provided for safe passage from one side of the shaft to the other. This passageway shall be not less than five feet in height and three feet in width.

E. Ice shall not be permitted to accumulate excessively in any shaft where miners are hoisted or lowered.

§ 45.1-161.157. Signaling; signal code.

A. Two independent means of signaling shall be provided between the top, bottom, and all intermediate landings of shafts, slopes, and surface inclines and the hoisting station. At least one of these means of signaling shall be audible to the hoisting engineer or other person operating the equipment. Bell cords shall be installed in shafts in such a manner as to prevent unnecessary movement of such cords within the shaft.

B. A uniform signal code approved by the Chief shall be in use at each mine and shall be at the cage station designated by the mine foreman.

§ 45.1-161.158. Inspections of hoisting equipment.

A. Before hoisting or lowering miners in a shaft, the hoisting engineer shall operate empty cages up and down each shaft at least one round trip at the beginning of each shift and after the hoist has been idle for one hour or more.

B. Before hoisting or lowering miners in slope and surface incline hoisting, the hoisting engineer shall operate empty cages at least one round trip at the beginning of each shift and after the hoist has been idle for one hour or more.

C. The hoisting engineer, at the time the inspections required by subsections A and B are performed, shall (i) inspect all cable or rope fastenings at all cages, buckets, or slope cars; (ii) inspect hammer locks and pins, thimbles, and clamps; (iii) inspect safety chains on buckets, cage or slope cars; (iv) inspect the braking system for malfunctions; (v) clean all excess oil and extraneous materials from the hoist housing construction; (vi) inspect the overwind, overtravel, and lilly switch or control from stopping at the collar and within 100 feet of the work deck; and (vii) check communications between the top house, work deck and work deck tugger house.

D. Hoisting rope on all cages or trips shall be inspected at the beginning of each shift by the hoisting engineer.

E. A test of safety catches on cages shall be made at least once each month. A written record shall be kept of such tests, and such record shall be available for inspection by interested persons.

F. Hoisting equipment including the headgear, cages, ropes, connections, links and chains, shaft guides, shaft walls, and other facilities shall be inspected daily by an authorized person designated by the operator. Such person shall also inspect all bull wheels and lighting systems on the head frame. Such person shall report immediately to the operator, or his agent, any defects found, and any such defect shall be corrected promptly. The person making such examination shall make a daily permanent record of such inspection, which shall be available for inspection by interested persons. If a hoist is used only during a weekly examination of an escapeway, then the inspection required by this subsection shall only be required to be completed weekly before the examination occurs.

G. Subsections A, B, C, and D shall not apply to automatically operated elevators.

§ 45.1-161.159. Hoisting engineers.

A. A certified hoisting engineer shall be either on duty continuously, or available within a reasonable time as determined by the Chief, to provide immediate transportation while any person is underground, where miners are transported into or out of underground areas of a mine by hoists or on surface inclines.

B. When miners are being hoisted or lowered in shafts, slopes, or on surface inclines, the loading and unloading of miners and movement of the cage, car, or trip shall be under the direction of an authorized person.

C. Subsections A and B shall not apply to automatically operated elevators that can be safely operated by any miner; however, a person qualified as an automatic elevator operator shall be available at such elevators within a reasonable time as determined by the Chief.

D. No operator, or his agent, of any mine worked by shaft, slope or incline shall place in charge of any engine or drum used for lowering or hoisting miners any but competent and sober hoisting engineers. No hoisting engineer in charge of such machinery shall allow any person, except such as may be designated for such purpose by the operator, or his agent, to interfere with any part of the machinery. No person shall interfere with or intimidate the hoisting engineer or automatic elevator operator in the discharge of his duties.

§ 45.1-161.160. Operations of hoisting equipment.

A. The speed of the cage, car, or trip in shafts, slopes, or on surface inclines shall not exceed 1,000 feet per minute when miners are being hoisted or lowered.

B. When moving the platform or work deck, all miners traveling thereon shall have safety belts secured.

C. No person shall ride on a loaded cage.

D. The number of persons riding in any cage or car at one time shall not exceed the maximum prescribed by the manufacturer. The Chief may prescribe a lesser number when necessary to ensure the safety of miners being transported.

E. Conveyances being lowered into a shaft in which miners are working shall be stopped at least twenty feet above the area where such miners are working.

F. Whenever miners are working at the bottom of a shaft, there shall be an adjustable ladder or chain ladder attached to the work deck to provide an additional means of escape. Such ladder shall be at least twenty feet in length.

G. All chokers and slings used to transport materials within a shaft or slope shall meet specifications established by the United States of America Standards Institute.

§ 45.1-161.161. Maintenance of hoisting equipment.

Hoists, ropes, cages, and other hoisting equipment shall be maintained in a safe operating condition. Hoisting ropes shall be replaced as soon as there is evidence of possible failure.

Unit 2

Safety And Health Regulations For Coal Mines

4 VAC 25-20-140 Hoisting Engineer

A. Applicants shall possess two years of practical mining experience and one year of hoisting experience under the direction of a certified hoisting engineer or appropriately related work experience approved by the chief. A certified hoisting engineer will verify the hoisting experience.

B. The applicant shall pass the hoisting engineer and gas detection examination.

C. After the examination has been successfully completed, the applicant shall obtain permission from the mine official to have a representative from the division to observe the applicant's operation of hoisting equipment at the mine. Permission shall be on company stationery, signed by the company official, and submitted to the division.

D. A certified hoisting engineer may act as an automatic elevator operator after completing the on-site demonstration required by 4 VAC 25-20-240 C.

E. A hoisting engineer must be recertified every five years by:

   1. Presenting written proof that he has performed hoisting engineer duties in his work during two of the last three years immediately preceding the expiration date: or
   2. Retaking or passing the practical demonstration section of the hoisting engineer examination and meeting requirements of subsection C of this section.

F. Failure to maintain education or training requirements shall result in

suspension of a person certification pending completion of continuing education or training. If the continuing education requirement is not met with in two years from the suspension date, the certification shall be revoked by the BCME.

G. The division shall send notice of any suspension to the last address the certified person reported to the division in accordance with 4 VAC 25-20-20 I. Upon request, DMME will provide the mine operator and other interested parties with a list of individuals whose certification is in suspension or has been revoked.

<u>Questions and answers for review:</u>

1. Cages used for hoisting men shall have:
   Answer: Enclosed sides, adequate steel bonnets, and substantial construction.

2. The floor of cages shall be designed and constructed to:
   Answer: Be impossible for miners feet or body to enter any opening in the bottom of the cage and carry the load.

3. A test of safety catches on cages shall be made:
   Answer: Monthly

4. The speed of cages when miners are being transported shall not exceed:
   Answer: 1000 feet per minute

5. Hoisting machinery shall be maintained in:
   Answer: Safe operating condition.

6. Platforms or work decks used for transporting miners or materials shall be equipped with:
   Answer: Leveling indicators

7. How many turns of rope must remain on the drum when extended to its maximum working length?
   Answer: Three turns.

8. Hoisting ropes shall be fastened to it's load by:
   Answer: A spelter filled socket, or thimble and adequate number of clamps.

9. An indicator showing the position of the cage, shall be in clear view of the hoisting engineer unless:
   Answer: The position of the car or trip is clearly visible to the hoisting engineer or other person operating the equipment at all times.

10. Hoist "rope" on all cages except automatically operated elevators, shall be inspected:
    Answer: At the beginning of each shift by hoisting engineer.

11. Ropes used to hoist or lower men shall have a safety factor of:
    Answer: 10 to 1

12. Hoist shall be equipped with brakes capable of stopping and holding a:
    Answer: Fully loaded unbalanced cage at any point in the shaft.

13. The lilly, simplex, or other safety controller is a multi-purpose safety device attached to the:
    Answer: Drum shaft

14. Safety factor of ropes used to hoist or lower coal:

Answer: 5 to 1

15. Hoist used to transport persons at a coal mine shall be equipped with:
    Answer: Over speed, over wind and automatic stop controls.

16. What must be done before hoisting or lowering men when the cage has been idle for more than one hour?
    Answer: Empty cages must be operated up and down the shaft one complete trip.

17. Any rope attached to a cage or man car or trip used for hoisting or lowering men or materials shall be provided with:
    Answer: Two bridle chains or cables.

18. Platforms or work decks shall be maintained in reasonably level position while:
    Answer: Transporting men and materials.

19. Defects found during daily hoist inspections shall be:
    Answer: Reported to operator or agent and corrected promptly.

20. The purpose of the safety dogs is to:
    Answer: Clamp down on the shaft guide if the rope slips or fails.

21. The two basic types of clutches used on hoist are:
    Answer: Centrifugal clutch & friction clutch

22. What device engages or dis-engages the drum from the hoist motor?
    Answer: Clutch

23. The main parts of a disc brake are:
    Answer: Disc, pads, and operating mechanism.

24. Brakes on hoist used to transport persons shall be capable:
    Answer: Of stopping and holding a fully loaded platform or cage.

25. How far should the drum flange extend above the spooled cable?
    Answer: 4 inches.

26. All self-dumping cages used to transport personnel shall be equipped with:
    Answer: Locking device to prevent tilting of the cage.

27. What is the purpose of the over-speed in the hoisting mechanism?
    Answer: Designed to de-energized the hoist in the event of excessive speed.

28. Signaling codes shall be in use at each shaft mine and approved by:
    Answer: The Chief, Division of Mines

29. The two basic types of mine hoist are:
    Answer: Friction, and drum hoist

30. One of the methods of communication between shaft station and hoist room shall give a signal which can be heard at all times by:
    Answer: Hoisting Engineer

31. All suspended work decks and platforms shall be equipped with:
    Answer: Safety belts and guard rails.

32. Who can ride on a cage loaded with supplies?
    Answer: Not any one.

33. Who shall inspect all bull wheels and lighting systems on the head frame?
    Answer: Authorized person designated by the operator.

34. How is the number of persons that can ride in any cage at one time determined?
Answer: Number persons riding shall not exceed maximum prescribed by the manufacturer.

35. What shall be provided at the bottom of each hoisting shaft and t intermediate landings?
Answer: A run around.

36. What is a sheave?
Answer: A grooved wheel which supports the hoist rope.

37. The head frame for a drum hoist holds:
Answer: Head sheave and wire rope

38. What is a “safety dog” on a cage used for?
Answer: An emergency braking device.

39. The shaft lining is:
Answer: The sides of the shaft

40. The safety gate is:
Answer: A guard across a landing of the shaft.

41. The purpose of shaft guides are:
Answer: Keep the conveyance or age in proper position.

42. The “skip” is used to transport:
Answer: Ore, waste, coal and equipment.

43. At a shaft mine the “collar” is referred to as:
Answer: The area surrounding the shaft opening.

44. The hoist must be taken out of service:
    Answer: When there is evidence of damage or failure of hoist parts.

45. A daily visual examination of hoisting equipment should include the following:
    Answer: Headgear, cages, ropes, connections, links, chains, shaft guides, shaft walls, bull wheels, lighting systems and head frame.

46. The depth indicator for the shaft shows what?
    Answer: The position of cage or trip at any point in the shaft.

47. How does a hoist man check the over-wind to ascertain it is functioning properly?
    Answer: Manually operate the over-wind protection devices.

48. What are the requirements for certification for a hoisting engineer?
    Answer: Two years practical mining experience, pass hoist engineer and gas detection examination and one year hoisting experience.

49. When is a person that is certified to operate hoisting equipment required to be on duty?
    Answer: While any person is underground except where automatic elevators are used.

50. Who can certify personnel to operate a manually controlled hoist?
    Answer: Virginia Division of Mines, Board of Examiners.

51. What is the minimum score an applicant must make to pass the hoist man examination?
    Answer: 80%

52. Who can operate automatic elevator?

Answer: Any workman which can operate it safely.

53. Conveyances used to haul men and material shall have a six inch retaining edge to prevent:
    Answer: Materials or objects from falling back into the shaft.

54. Where shall stopblocks and derails be located?
    Answer: Near the top of immediate landings of slopes, near the top of surface inclines, near the approaches to shaft landings.

55. Shafts shall be equipped with safety gates at:
    Answer: Each landing and the top of shafts.

56. What shall not be permitted to accumulate excessively on the walls of any shaft where men are hoisted or lowered?
    Answer: Ice

57. Whenever men are working at the bottom of the shaft there shall be an adjustable ladder or chain attached to the work deck to provide an additional means of escape. Such ladder shall be at least?
    Answer: 20 feet in length.

58. Conveyances being lowered into a shaft in which miners are working shall be stopped how far above the miners?
    Answer: Twenty feet.

59. What supplies or tool can be transported on the same cage with miners?
    Answer: Only small hand tools that can be carried on the person.

60. What is the center of a wire hoisting rope called?
    Answer: Core

61. The wires which bear against the sheave or drum are called?
    Answer: Crown wires.

62. The breaking strength of the rope divided by the load on the rope is called:
    Answer: Safety factor

63. A rope with 200,000 pound breaking strength carrying a normal load which includes a cage weighing 10,000 pounds and 5 ton of rock dust has a safety factor of:
    Answer: 10 to 1

64. When shall wire ropes which are kinked or looped be taken out of service?
    Answer: Immediately

65. What will cause a wire rope to be weakened?
    Answer: Kinking, too small a sheave and too small a drum.

66. If a wire rope has six broken wires in one lay, should the rope be removed from service?
    Answer: Yes, it should be removed.

67. When there is evidence of corrosion in a wire rope, should it be removed from service?
    Answer: Yes.

68. If a rope has 65% crown wear, it would be required:
    Answer: To be removed from the hoist.

69. f you have a 2 inch diameter wire rope and you are using clips and thimbles to connect the rope to the load, how many clips are required and what is the spacing of the clips?
    Answer: 7 clips and spaced 12 inches apart.

70. When using thimble and clips to fasten a rope to its load, the distance between the clips should not be less than?
    Answer: Six times the diameter of rope.

Unit 3

Code of Federal Regulations (30 CFR)

75.382 Mechanical escape facilities.

(a) Mechanical escape facilities shall be provided with overspeed, overwind, and automatic stop controls.

(b) Every mechanical escape facility with a platform, cage, or other device shall be equipped with brakes that can stop the fully loaded platform, cage, or other device.

(c) Mechanical escape facilities, including automatic elevators, shall be examined weekly. The weekly examination of this equipment may be conducted at the same time as a daily examination required by §75.1400-3.

(1) The weekly examination shall include an examination of the headgear, connections, links and chains, overspeed and overwind controls, automatic stop controls, and other facilities.

(2) At least once each week, the hoist shall be run through one complete cycle of operation to determine that it is operating properly.

(d) A person trained to operate the mechanical escape facility always shall be available while anyone is underground to provide the mechanical escape facilities, if required, to the bottom of each shaft and slope opening that is part of an escapeway within 30 minutes after personnel on the surface have been notified of an emergency requiring evacuation. However, no operator is required for automatically operated cages, platforms, or elevators.

(e) Mechanical escape facilities shall have rated capacities consistent with the loads handled.

(f) Manually-operated mechanical escape facilities shall be equipped with indicators that accurately and reliably show the position of the facility.

(g) Certification. The person making the examination as required by paragraph (c) of this section shall certify by initials, date, and the time that the examination was made. Certifications shall be made at or near the facility examined.

Subpart O--Hoisting and Mantrips

30 CFR § 75.1400

Hoisting equipment; general.

(a) Every hoist used to transport persons shall be equipped with overspeed, overwind, and automatic stop controls.

(b) Every hoist handling a platform, cage, or other device used to transport persons shall be equipped with brakes capable of stopping the fully loaded platform, cage, or other device.

(c) Cages, platforms, or other devices used to transport persons in shafts and slopes shall be equipped with safety catches or other no less effective devices approved by the Secretary that act quickly and effectively in an emergency. Such catches or devices shall be tested at least once every two months.

(d) Hoisting equipment, including automatic elevators, used to transport persons shall be examined daily.

(e) Where persons are transported into or out of a mine by a hoist, a qualified hoisting engineer shall be on duty while any person is underground. No such engineer, however, shall be required for automatically operated cages, platforms, or elevators.

30 CFR § 75.1400-1

Hoists; brakes, capability.

Brakes on hoists used to transport persons shall be capable of stopping and holding the fully loaded platform, cage, or other device at any point in the shaft, slope, or incline

30 CFR § 75.1400-2

Hoists; tests of safety catches; records.

A record shall be made in a book of the tests, required by §75.1400, of the safety catches or other devices approved by the Secretary. Each entry shall be signed by the person making the tests and countersigned by a responsible official.

30 CFR § 75.1400-3

Daily examination of hoisting equipment.

Hoists and elevators shall be examined daily and such examinations shall include, but not be limited to, the following:

(a) *Elevators.* A visual examination of the rope for wear, broken wires, and corrosion, especially at excessive strain points such as near the attachments and where the rope rests on sheaves;

(b) *Hoists and elevators.* (1) An examination of the rope fastenings for defects;

(2) An examination of safety catches;

(3) An examination of the cages, platforms, elevators, or other devices for loose, missing or defective parts;

(4) An examination of the head sheaves to check for broken flanges, defective bearings, rope alignment, and proper lubrication; and

(5) An observation of the lining and all other equipment and appurtenances installed in the shaft.

30 CFR § 75.1400-4

Certifications and records of daily examinations.

At the completion of each daily examination required by §75.1400, the person making the examination shall certify, by signature and date, that the examination has been made. If any unsafe condition is found during the examinations required by §75.1400-3, the person conducting the examination shall make a record of the condition and the date. Certifications and records shall be retained for one year.

30 CFR § 75.1401

Hoists; rated capacities; indicators.

Hoists shall have rated capacities consistent with the loads handled. An accurate and reliable indicator of the position of the cage, platform, skip, bucket, or cars shall be provided.

30 CFR § 75.1401-1

Hoists; indicators.

The indicator required by §75.1401 of this subpart shall be placed so that it is in clear view of the hoisting engineer and shall be checked daily to determine its accuracy.

30 CFR § 75.1402

Communication between shaft stations and hoist room.

There shall be at least two effective methods approved by the Secretary of signaling between each of the shaft stations and the hoist room, one of which shall be a telephone or speaking tube.

30 CFR § 75.1402-1

Communication between shaft stations and hoist room.

One of the methods used to communicate between shaft stations and the hoist room shall give signals which can be heard by the hoisting engineer at all times while men are underground.

30 CFR § 75.1402-2

Tests of signaling systems.

Signaling systems used for communication between shaft stations and the hoist room shall be tested daily.

30 CFR § 75.1403

Other safeguards.

Other safeguards adequate, in the judgment of an authorized representative of the Secretary, to minimize hazards with respect to transportation of men and materials shall be provided.

30 CFR § 75.1403-1

General criteria.

(a) Sections 75.1403-2 through 75.1403-11 set out the criteria by which an authorized representative of the Secretary will be guided in requiring other safeguards on a mine-by-mine basis under §75.1403. Other safeguards may be required.

(b) The authorized representative of the Secretary shall in writing advise the operator of a specific safeguard which is required pursuant to §75.1403 and shall fix a time in which the operator shall provide and thereafter maintain such safeguard. If the safeguard is not provided within the time fixed and if it is not maintained thereafter, a notice shall be issued to the operator pursuant to section 104 of the Act.

(c) Nothing in the sections in the §75.1403 series in this Subpart O precludes the issuance of a withdrawal order because of imminent danger

30 CFR § 75.1403-2

Criteria--Hoists transporting materials; brakes.

Hoists and elevators used to transport materials should be equipped with brakes capable of stopping and holding the fully loaded platform, cage, skip, car, or other device at any point in the shaft, slope, or incline.

30 CFR § 75.1403-3

Criteria--Drum clutch; cage construction.

(a) The clutch of a free-drum on a personnel hoist should be provided with a locking mechanism or interlocked with the brake to prevent accidental withdrawal of the clutch.

(b) Cages used for hoisting persons should be constructed with the sides enclosed to a height of at least six feet and should have gates, safety chains, or bars across the ends of the cage when persons are being hoisted or lowered.

(c) Self-dumping cages, platforms, or other devices used for transportation of persons should have a locking device to prevent tilting when persons are transported.

(d) An attendant should be on duty at the surface when persons are being hoisted or lowered at the beginning and end of each shift.

(e) Precautions should be taken to protect persons working in shaft sumps.

(f) Workers should wear safety belts while doing work in or over shafts.

30 CFR § 75.1403-4

Criteria--Automatic elevators.

(a) The doors of automatic elevators should be equipped with interlocking switches so arranged that the elevator car will be immovable while any door is opened or unlocked, and arranged so that such door or doors cannot be inadvertently opened when the elevator car is not at a landing.

(b) A "Stop" switch should be provided in the automatic elevator compartment that will permit the elevator to be stopped at any location in the shaft.

(c) A slack cable device should be used where appropriate on automatic elevators which will automatically shut-off the power and apply the brakes in the event the elevator is obstructed while descending.

(d) Each automatic elevator should be provided with a telephone or other effective communication system by which aid or assistance can be obtained promptly.

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30 CFR § 75.1429

Guide ropes.

WIRE ROPES

Source: Sections 75.1429 through 75.1438 appear at 48 FR 53239, Nov. 25, 1983, unless otherwise noted.

If guide ropes are used in shafts for personnel hoisting applications other than shaft development, the nominal strength (manufacturer's published catalog strength) of the guide rope at installation shall meet the minimum value calculated as follows: Minimum value = Static Load x 5.0.

30 CFR § 75.1430

Wire ropes; scope.

(a) Sections 75.1430 through 75.1438 apply to wire ropes in service used to hoist--

(1) Persons in shafts or slopes underground; or

(2) Loads in shaft or slope development when persons work below the suspended loads.

(b) These standards do not apply to wire ropes used for elevators.

30 CFR § 75.1431

Minimum rope strength.

At installation, the nominal strength (manufacturer's published catalog strength) of wire ropes used for hoisting shall meet the minimum rope strength values obtained by the following formulas in which "L" equals the maximum suspended rope length in feet:

(a) *Winding drum ropes* (all constructions, including rotation resistant).

For rope lengths less than 3,000 feet:

Minimum Value = Static Load x (7.0--0.001L)

For rope lengths 3,000 feet or greater:

Minimum Value = Static Load x 4.0

(b) *Friction drum ropes.*

For rope lengths less than 4,000 feet:

Minimum Value = Static Load x (7.0--0.0005L)

For rope lengths 4,000 feet or greater:

Minimum Value = Static Load x 5.0

(c) *Tail ropes* (balance ropes).

Minimum Value = Weight of Rope x 7.0

[48 FR 53239, Nov. 25, 1983; 48 FR 54975, Dec. 8, 1983]

30 CFR § 75.1432

Initial measurement.

After initial rope stretch but before visible wear occurs, the rope diameter of newly installed wire ropes shall be measured at least once in every third interval of active length and the measurements averaged to establish a baseline for subsequent measurements. A record of the measurements and the date shall be made by the person taking the measurements. This record shall be retained until the rope is retired from service.

30 CFR § 75.1433

Examinations.

(a) At least once every fourteen calendar days, each wire rope in service shall be visually examined along its entire active length for visible structural damage, corrosion, and improper lubrication or dressing. In addition, visual examination for wear and broken wires shall be made at stress points, including the area near attachments, where the rope rests on sheaves, where the rope leaves the drum, at drum crossovers, and at change-of-layer regions. When any visible condition that results in a reduction of rope strength is present, the affected portion of the rope shall be examined on a daily basis.

(b) Before any person is hoisted with a newly installed wire rope or any wire rope that has not been examined in the previous fourteen calendar days, the wire rope shall be examined in accordance with paragraph (a) of this section.

(c) At least once every six months, nondestructive tests shall be conducted of the active length of the rope, or rope diameter measurements shall be made--

(1) Wherever wear is evident;

(2) Where the hoist rope rests on sheaves at regular stopping points;

(3) Where the hoist rope leaves the drum at regular stopping points; and

(4) At drum crossover and change-of-layer regions.

(d) At the completion of each examination required by paragraph (a) of this section, the person making the examination shall certify, by signature and date, that the examination has been made. If any condition listed in paragraph (a) of this standard is present, the person conducting the examination shall make a record of the condition and the date. Certifications and records of examinations shall be retained for one year.

(e) The person making the measurements or nondestructive tests as required by paragraph (c) of this section shall record the measurements or test results and the date. This record shall be retained until the rope is retired from service.

30 CFR § 75.1434

Retirement criteria.

Unless damage or deterioration is removed by cutoff, wire ropes shall be removed from service when any of the following conditions occurs:

(a) The number of broken wires within a rope lay length, excluding filler wires, exceeds either--

(1) Five percent of the total number of wires; or

(2) Fifteen percent of the total number of wires within any strand;

(b) On a regular lay rope, more than one broken wire in the valley between strands in one rope lay length;

(c) A loss of more than one-third of the original diameter of the outer wires;

(d) Rope deterioriation from corrosion;

(e) Distortion of the rope structure;

(f) Heat damage from any source;

(g) Diameter reduction due to wear that exceeds six percent of the baseline diameter measurement; or

(h) Loss of more than ten percent of rope strength as determined by nondestructive testing.

30 CFR § 75.1435

Load end attachments.

(a) Wire rope shall be attached to the load by a method that develops at least 80 percent of the nominal strength of the rope.

(b) Except for terminations where use of other materials is a design feature, zinc (spelter) shall be used for socketing wire ropes. Design feature means either the manufacturer's original design or a design approved by a registered professional engineer.

(c) Load end attachment methods using splices are prohibited.

30 CFR § 75.1436

Drum end attachment.

(a) For drum end attachment, wire rope shall be attached--

(1) Securely by clips after making one full turn around the drum spoke;

(2) Securely by clips after making one full turn around the shaft, if the drum is fixed to the shaft; or

(3) By properly assembled anchor bolts, clamps, or wedges, provided that the attachment is a design feature of the hoist drum. Design feature means either the manufacturer's original design or a design approved by a registered professional engineer.

(b) A minimum of three full turns of wire rope shall be on the drum when the rope is extended to its maximum working length

30 CFR § 75.1437

End attachment retermination.

Damaged or deteriorated wire rope shall be removed by cutoff and the rope reterminated where there is

(a) More than one broken wire at an attachment;

(b) Improper installation of an attachment;

(c) Slippage at an attachment; or

(d) Evidence of deterioration from corrosion at an attachment.

30 CFR § 75.1438

End attachment replacement.

Wire rope attachments shall be replaced when cracked, deformed, or excessively worn.

Subpart O--Personnel Hoisting

Sec. 77.1400 Personnel hoists and elevators.

Except as provided in §77.1430, the sections in this Subpart O apply only to hoists and elevators, together with their appurtenances, that are used for hoisting persons.

Sec. 77.1401 Automatic controls and brakes.

Hoists and elevators shall be equipped with overspeed, overwind, and automatic stop controls and with brakes capable of stopping the elevator when fully loaded.

Sec. 77.1402 Rated capacity.

Hoists and elevators shall have rated capacities consistent with the loads handled.

Sec. 77.1402-1 Maximum load; posting.

The operator shall designate the maximum number of men permitted to ride on each hoist or elevator at one time; this limit shall be posted on each elevator and on each landing.

Sec. 77.1403 Daily examination of hoisting equipment.

Hoists and elevators shall be examined daily and such examinations shall include, but not be limited to, the following:

(a) *Elevators.* (1) A visual examination of the ropes for wear, broken wires, and corrosion, especially at excessive strain points such as near the attachments and **where** the rope rests on the sheaves;(2) An examination of the elevator for loose, missing or defective parts;

(b) *Hoists and elevators.* (1) An examination of the rope fastenings for defects;(2) An examination of sheaves for broken flanges, defective bearings, rope alignment, and proper lubrication; and(3) An examination of the automatic controls and brakes required under §77.1401.

Sec. 77.1404 Certifications and records of daily examinations.

At the completion of each daily examination required by §77.1403, the person making the examination shall certify, by signature and date, that the examination has been made. If any unsafe condition is found during the examinations required by §77.1403, the person conducting the examination shall make a record of the condition and the date. Certifications and records shall be retained for one year.

Sec. 77.1405 Operation of hoisting equipment after repairs.

Empty conveyances shall be operated at least one round trip before hoisting persons after any repairs.

WIRE ROPES

Sec. 77.1430 Wire ropes; scope.

(a) Sections 77.1431 through 77.1438 apply to wire ropes in service used to hoist--

(1) Persons in shafts and slopes underground;

(2) Persons with an incline hoist on the surface; or

(3) Loads in shaft or slope development when persons work below suspended loads.

(b) These standards do not apply to wire ropes used for elevators.

Sec. 77.1431 Minimum rope strength.

At installation, the nominal strength (manufacturer's published catalog strength) of wire ropes used for hoisting shall meet the minimum rope strength values obtained by the following formulas in which "L" equals the maximum suspended rope length in feet:

(a) *Winding drum ropes* (all constructions, including rotation resistant).

For rope lengths less than 3,000 feet:
Minimum Value=Static Load x (7.0-0.001L)
For rope lengths 3,000 feet or greater:
Minimum Value=Static Load x 4.0

(b) *Friction drum ropes.*

For rope lengths less than 4,000 feet:
Minimum Value=Static Load x (7.0-0.0005L)
For rope lengths 4,000 feet or greater:
Minimum Value=Static Load x 5.0

(c) *Tail ropes* (balance ropes).

Minimum Value=Weight of Rope x 7.0

Sec. 77.1432 Initial measurement.

After initial rope stretch but before visible wear occurs, the rope diameter of newly installed wire ropes shall be measured at least once in every third interval of active length and the measurements averaged to establish a baseline for subsequent measurements. A record of the measurements and the date shall be made by the person taking the measurements. This record shall be retained until the rope is retired from service.

Sec. 77.1433 Examinations.

(a) At least once every fourteen calendar days, each wire rope in service shall be visually examined along its entire active length for visible structural damage, corrosion, and improper lubrication or dressing. In addition, visual examination for wear and broken wires shall be made at stress points, including the area near attachments, where the rope rests on sheaves, where the rope leaves the drum, at drum crossovers, and at change-of-layer regions. When any visible condition that results in a reduction of rope strength is present, the affected portion of the rope shall be examined on a daily basis.

(b) Before any person is hoisted with a newly installed wire rope or any wire rope that has not been examined in the previous fourteen calendar days, the wire rope shall be examined in accordance with paragraph (a) of this section.

(c) At least once every six months, nondestructive tests shall be conducted of the active length of the rope, or rope diameter measurements shall be made—

(1) Wherever wear is evident;

(2) Where the hoist rope rests on sheaves at regular stopping points;

(3) Where the hoist rope leaves the drum at regular stopping points; and

(4) At drum crossover and change-of-layer regions.

(d) At the completion of each examination required by paragraph (a) of this section, the person making the examination shall certify, by signature and date, that the examination has been made. If any condition listed in paragraph (a) of this standard is present, the person conducting the examination shall make a record of the condition and the date. Certifications and records of examinations shall be retained for one year.

(e) The person making the measurements or nondestructive tests as required by paragraph (c) of this section shall record the measurements or test results and the date. This record shall be retained until the rope is retired from service.

Sec. 77.1434 <u>Retirement criteria.</u>

Unless damage or deterioration is removed by cutoff, wire ropes shall be removed from service when any of the following conditions occurs:

(a) The number of broken wires within a rope lay length, excluding filler wires, exceeds either--

(1) Five percent of the total number of wires; or

(2) Fifteen percent of the total number of wires within any strand;

(b) On a regular lay rope, more than one broken wire in the valley between strands in one rope lay length;

(c) A loss of more than one-third of the original diameter of the outer wires;

(d) Rope deterioriation from corrosion;

(e) Distortion of the rope structure;

(f) Heat damage from any source;

(a) Diameter reduction due to wear that exceeds six percent of the baseline diameter measurement; or

(b) Loss of more than ten percent of rope strength as determined by nondestructive testing.

Sec. 77.1435 Load end attachments.

(a) Wire rope shall be attached to the load by a method that develops at least 80 percent of the nominal strength of the rope.

(b) Except for terminations where use of other materials is a design feature, zinc (spelter) shall be used for socketing wire ropes. Design feature means either the manufacturer's original design or a design approved by a registered professional engineer.

(c) Load end attachment methods using splices are prohibited.

Sec. 77.1436 Drum end attachment.

(a) For drum end attachment, wire rope shall be attached--

(1) Securely by clips after making one full turn around the drum spoke;

(2) Securely by clips after making one full turn around the shaft, if the drum is fixed to the shaft; or

(3) By properly assembled anchor bolts, clamps, or wedges, provided that the attachment is a design feature of the hoist drum. Design feature means either the manufacturer's original design or a design approved by a registered professional engineer.

(b) A minimum of three full turns of wire rope shall be on the drum when the rope is extended to its maximum working length.

Sec. 77.1437 End attachment retermination.

Damaged or deteriorated wire rope shall be removed by cutoff and the rope reterminated where there is—

(a) More than one broken wire at an attachment;

(b) Improper installation of an attachment;

(c) Slippage at an attachment; or

(d) Evidence of deterioration from corrosion at an attachment.

Sec. 77.1438 End attachment replacement.

Wire rope attachments shall be replaced when cracked, deformed, or excessively worn.

Questions and answers for review:

1. When working on top of cages over open shafts and slopes personnel shall:
   Answer: Wear safety belts and have lines secured

2. What shall cages, platforms, or other devices used to transport persons in shafts and slopes be equipped with?
   Answer: Safety catches

3. What capacities shall Hoist be rated for?
   Answer: Capacities consistent with loads handled

4. How shall cages used for hoisting persons be constructed?
   Answer: Sides at least 6 feet high and should have gates, safety chains, or bars across the ends.

5. What shall self-dumping cages, platforms, or other devices used for the transportation of persons have?
   Answer: A locking device to prevent tilting when persons are transported.

6. A hoist used to transport persons shall be equipped with:
   Answer: Over speed, over wind, and automatic stop controls

7. Hoist handling a platform, cage, or other device used to transport persons shall be equipped with:
   Answer: Brakes capable of stopping the fully loaded platform, cage, or other device

8. How often are safety catches on hoist required to be tested?
   Answer: State regulations require to be tested monthly and Federal

regulations require safety catches to be checked at least once every two months.

9. An accurate and reliable indicator for hoist shall be:
   Answer: Placed so that it is in clear view of the hoisting Engineer and shall be checked daily to determine its accuracy.

10. Automatic elevators should be equipped with:
    Answer: Interlocking switches which prevent movement of the elevator, while any door is open.

11. Automatic elevators shall be equipped with doors which:
    Answer: Cannot be inadvertently opened when the elevator car is not at a landing.
12. Automatic elevator compartments should be provided with:
    Answer: A stop switch that will permit the elevator to be stopped at any location in the shaft.

13. When shall hoist equipment, including automatic elevators, used to transport persons be examined?
    Answer: Daily

14. Where persons are transported into or out of a mine by a hoist, except automatically operated cages, platforms, or elevators, who must be on duty?
    Answer: A qualified hoisting engineer.

15. Records for safety catch testing shall be recorded and signed by:
    Answer: The person making the tests and countersigned by a responsible official.

16. Hoist and elevators shall be examined daily and the examination shall include:
    Answer: Elevators, hoist, ropes, fastenings, safety catches, cages, platforms, and head sheaves.

17. At the completion of daily hoist examinations a record must be:
    Answer: Completed by the person making he examination and shall be retained for one year.

18. Signaling between each shaft station and the hoist room shall be accomplished by:
    Answer: Two effective methods approved by Secretary, one of which shall be a telephone.

19. How often shall signaling systems between shaft stations and the hoist room be tested?
    Answer: Daily

Unit 4

A. EXAMPLE Of DAILY INSPECTIONS OF HOISTING EQUIPMENT

Date ______________________________ **Time** ______________________

Note: Use check (√) mark after items listed if in safe operating condition. If defects or unsafe conditions are found, state action taken and promptly report to the operator or agent. Defects shall be corrected promptly.

Items 1 through 17 shall be entered DAILY	**Check Mark (√)**	**Comments**
1. Visual examination of hoist ropes for wear, broken wires & corrosion, especially at excessive strain points near attachments and where ropes rests on sheaves.		
2. Examine rope fastenings for defects, connections, links and safety chains, alignment, and lubrication.		
3. Examine cages, platforms, elevators, or other devices for loose missing or defective parts.		
4. Examine head sheaves for broken flanges, defective bearings, rope alignment, & proper lubrication		
5. Examine head frame, headgear, bull wheels, lighting systems, & other facilities		
6. Examine shaft guides, shaft walls, lining &all other equipment & appurtenances installed in the shaft.		
7. Examine overspeed, overwind, over travel, Lilly switch, automatic stop controls & stop switch.		
8. Examine braking systems		
9. Examine slack cable device, which will automatically shut off power and apply brakes in the event the elevator is obstructed while descending.		
10. Anchorage of hoist; check for loose bolts, etc.		
11. Cages, platforms, elevators or other devices such as skip, bucket, or cards position indicator.		
12. Test of signaling systems, used for communication between shaft stations and the hoist room. Telephone or other effective communication system by which aid can be obtained promptly.		
13. 3 wraps of rope around drum; fastening to spoke, etc.		
14. Cage operated one round trip before men transported.		
15. Interlocking switches on doors or gates; landing gates or doors.		
16. Examine safety catches		
17. Examine hoist housing construction to ensure clean of excess oil & extraneous materials		
Test of safety catches (monthly) Date Tested: ______ ______________ Countersigned:___________________		

Signature by examiner (Authorized Person) **Signed** ____

AN EXAMPLE OF A WIRE ROPE EXAMINATION
At least every 14 Calendar day

Date: _____________ **Time**: ____________

At least every 14 calendar days, each wire rope in service shall be visually examined along its entire active length for visible structural damage, corrosion and improper lubrication or dressing. In addition, visual examination for wear and broken wires shall be made at stress points, including the area near the attachments, where the rope rest on sheaves, where the rope leaves the drum, at drum crossovers, and at change-of-layer regions. Where any visible condition that results in a reduction of rope strength is present, the affected portion of rope shall be examined on a daily basis.

Note: Use check (√) mark after items listed if in safe operating condition. If defects or unsafe conditions are found, state action taken and promptly report to the operator or agent. Defects shall be corrected promptly.

Items shall be entered at least every 14 calendar days	**Check Mark (√)**					**Comments**
		#1	#2	#3	#4	
1. Visual examination of hoist ropes for wear, broken wires & corrosion, especially at excessive strain points near attachments and where ropes rests on sheaves.						
2. Examine rope fastenings for defects, connections, links and safety chains, alignment, and lubrication.						
3. Examine Hoist Ropes: • Rope at attachments on cage end • Rope at attachment on counterweight end • Ropes at head sheaves with cage up • Ropes at head sheaves with counterweight up • Rope between head sheave and cage with cage up • Rope between head sheave and counterweight with counterweight up • Rope at drum with cage up • Rope at drum with counter weight up • Remaining length of rope						
4. Examine Balance Ropes: • Rope at socket • Rope during slow speed • Rope at clamps						

• Ropes travel through guide timbers						
5. Examine Guide Ropes: • Rope at connection in headframe • Rope between connection • Rope at connection in sump						
6. Examine Hoist House • Hoist drum and threads • Housekeeping • Lights						
7. Examine Headframe • Cage wood retarder • Counterweight wood retarder • Structure • Lights						
8. Examine head sheaves for broken flanges, defective bearings, rope alignment, & proper lubrication						
9. Examine head frame, headgear, bull wheels, lighting systems, sheaves, flanges, bearings, lubrication & other facilities						
10. Examine (3) wraps of rope around drum; fastening to spoke, etc.						
11. Examine Shaft Bottom • Wood retarders • Sump • Balance rope guide timbers						

Signature by examiner **Signed**
(Authorized Person)

AN EXAMPLE OF A DAILEY INSPECTION OF HOISTING EQUIPMENT

DAILY INSPECTIONS OF HOISTING EQUIPMENT

Date ______________________________ **Time** ______________________________ **Shift** ___________

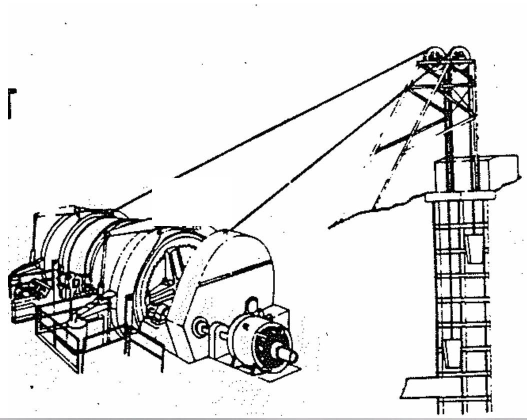
Note: Use check (√) mark after items listed if in safe operating condition. If unsafe conditions are noted, state action taken:

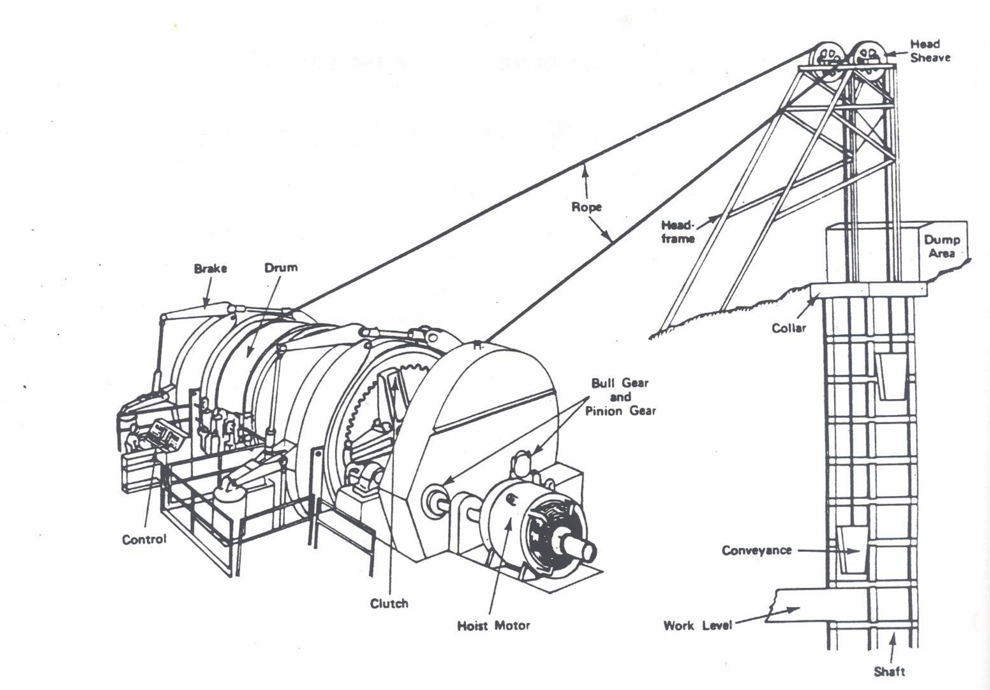
Items 1 through 13 shall be entered DAILY	Check Mark (√)	Comments
1. Visual examination of hoist ropes.		
2. Rope fastening, alignment, and lubrication.		
3. Safety catches.		
4. Examination of cage, platform, elevators, etc.		
5. Head sheaves, flanges, bearings, lubrication.		
6. Ride top of cage or elevator to check guides buttons, power wires, etc.		
7. Overwind, overspeed, and automatic stop controls.		
8. Anchorage of hoist; check for loose bolts, etc.		
9. Cage, platform, skip, bucket, or cards position indicator.		
10. Signal systems.		
11. Three wraps of rope around drum; fastening to spoke, etc.		
12. Cage operated one round trip before men transported.		
13. Landing gates or doors.		
14. Test of safety catches (monthly) Date: _______________		

Signature by examiner **Signed** ________________________________

Unit 5

MINE HOIST



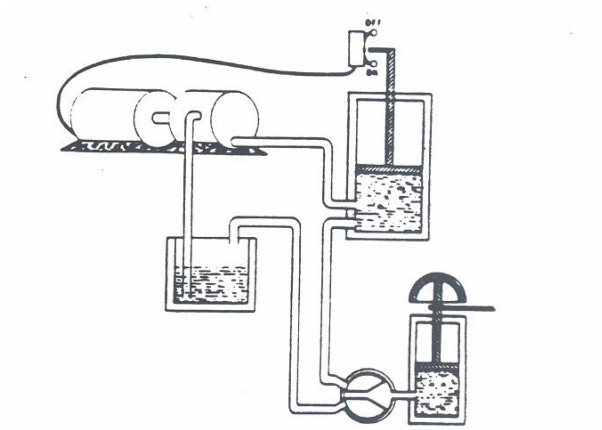


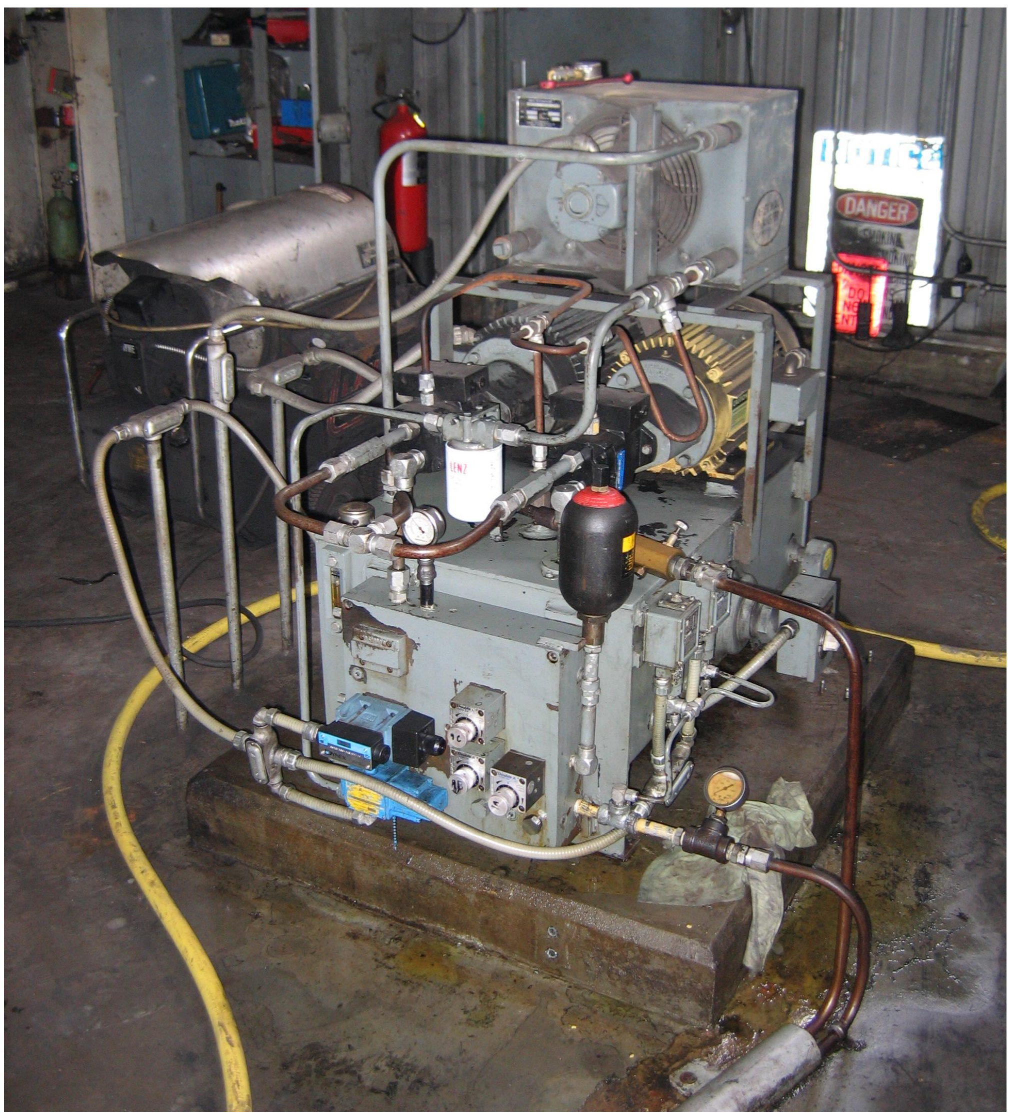
The MINE HOIST lowers men and materials into the mine and raises men, materials, ore and waste out of the mine.

The principal parts of the hoist are:

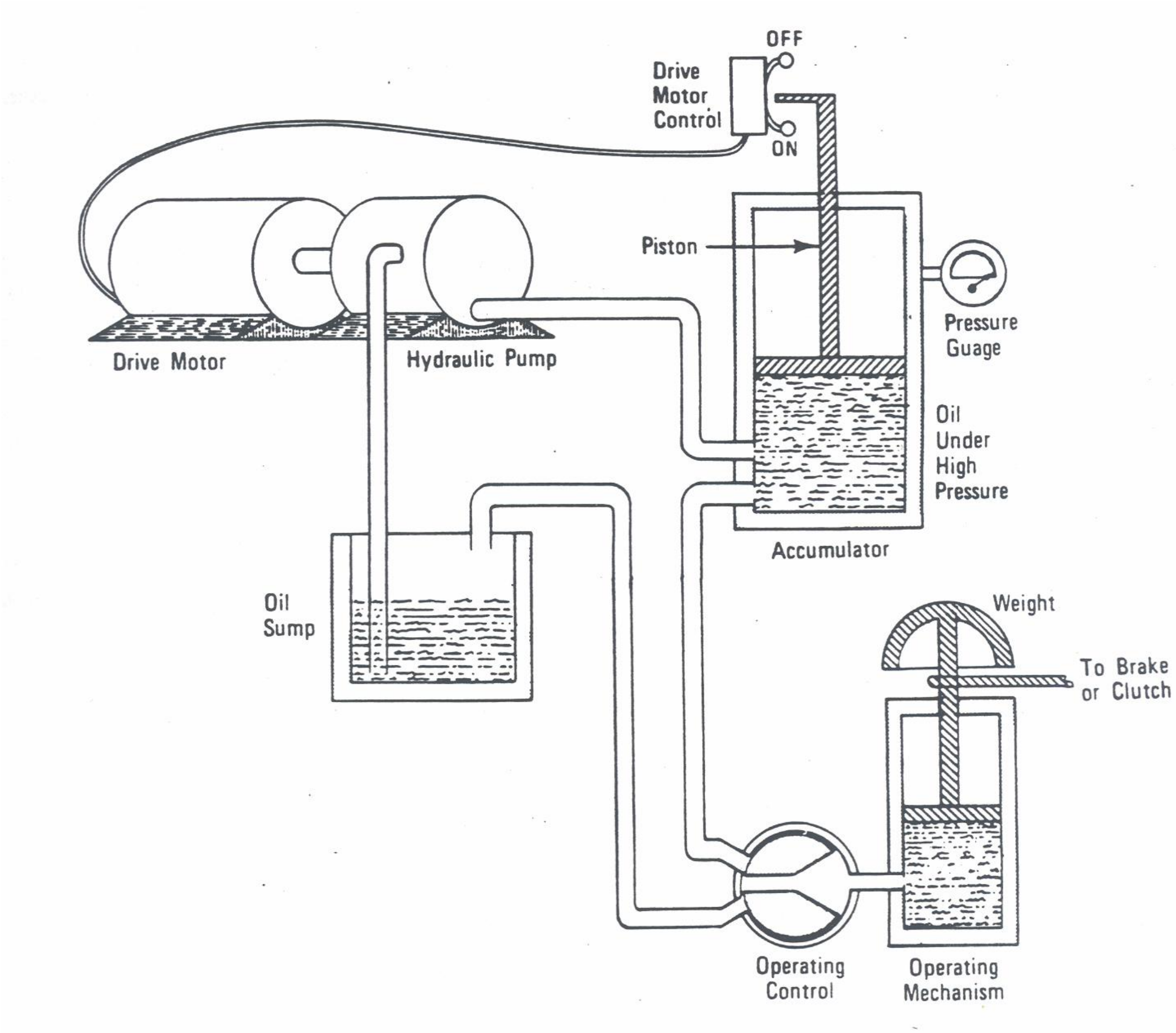
- MINE SHAFT-the path from the surface to the underground workings;
- COLLAR-the area surrounding the surface opening of the shaft;
- DUMP AREA-the area where ore and waste are deposited;
- WORK LEVEL-the mine level from which ore or waste is being hoisted;
- CONVEYANCE-the platform on which men, materials ore and waste are hoisted/lowered;
- HEADFRAME-the structure which holds the head sheave;
- HEADSHEAVE-the grooved wheel which supports the rope;
- HOIST ROPE-the wire cable which raises and lowers the conveyance;
- HOIST DRUM or WHEEL-the drum or wheel which raises and lowers the hoist rope;
- HOIST MOTOR-the motor which turns the hoist drum or wheel;
- PINION and BULL GEARS-gears which connect the hoist motor to the hoist drum or the hoist wheel;
- CLUTCH-the device which engages or disengages the drum from the hoist motor;
- BRAKE-the device which slows, stops and holds the hoist rope;
- CONTROL-the station from which the hoist is operated.

<u>Unit 6</u>
HYDRAULIC SYSTEM





A Hydraulic System enables the hoist operator to apply or release the hoist brakes and to engage or disengage the clutch. These operations can be performed from a remote station with little effort from the operator. Controls cause oil under high pressure to force a piston or other mechanism to move and perform the desired work.



A basic hydraulic system consists of these parts:

- A hydraulic Pump that will pressurize oil.
- An electric Drive Motor that operates the pump.
- A Drive Motor Control that will start and stop the drive motor.

- An Accumulator that will store oil at high pressure. The accumulator is usually a cylinder and piston. Oil at high pressure is stored beneath the piston. The space about the piston may be filled with pressurized air to force the piston downward against the oil. Sometimes coiled springs or weights instead of high pressure air are used to force the piston against the oil.

- An Operating Control which the operator uses to control the flow of oil in the system.

- A Sump that stores oil at low pressure.

- An Operating Mechanism, usually a cylinder and piston, that does the work. This mechanism may apply or release the brake, or engage or disengage the clutch. If oil flows from the accumulator to the operating mechanism, the piston moves upward, lifts the weight and moves levers in one direction. If the oil flows from the operating mechanism to the sum, the piston moves downward because of the weight, and the levers move in the opposite direction.

The system works as follows:

- Using operating control, the operator allows oil to flow from the accumulator into the operating mechanism.

- The piston moves upward and may, for example, engage the clutch.

- When the operator wants to disengage the clutch, he/she again uses the operating control. Oil is allowed to flow from the operating mechanism to the sump.

- The piston in the operating mechanism will move downward because of the weight.

- As oil flows out of the accumulator, the accumulator piston moves downward. This movement causes the drive motor control to start the drive motor.

- The drive motor operates the pump which pumps oil from the sump to the accumulator.

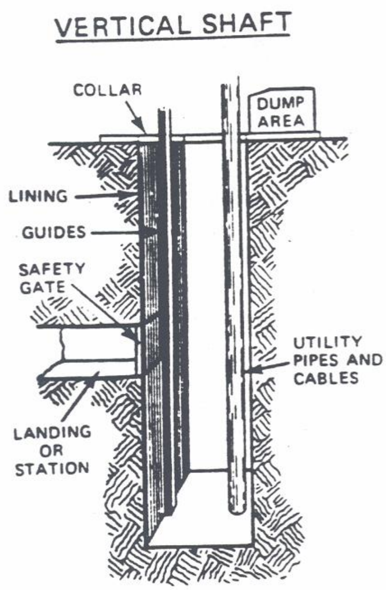
- This increase in oil raises the accumulator piston.

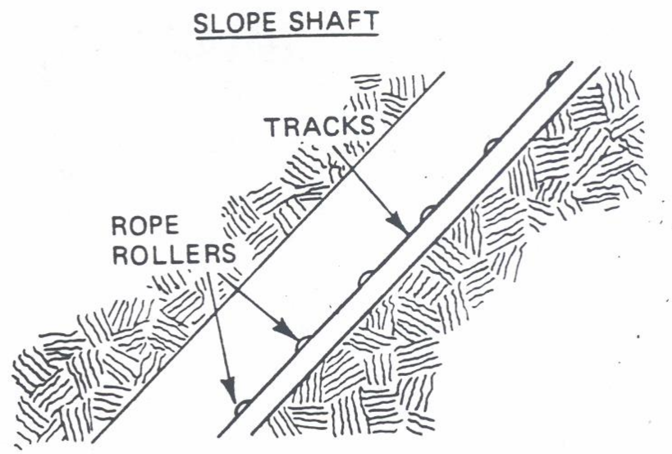
- When sufficient oil has been pumped, the upward movement of the accumulator piston shuts off the drive motor.

Unit 7

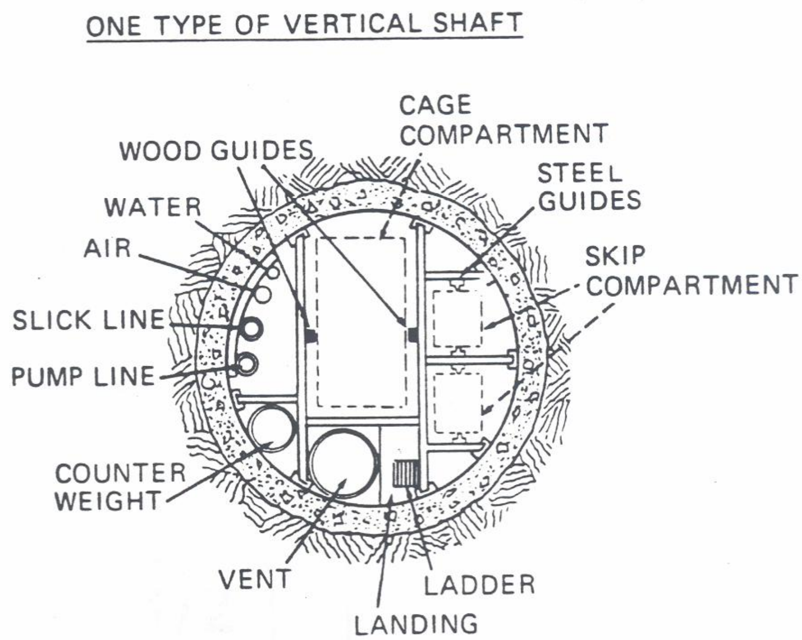
SHAFT

The Shaft provides a path for one or more conveyance, power cables, and communications and other control links. There are two types of shafts: vertical and slope.





A shaft may be divided into Compartments. Each compartment provides a path for a conveyance, counter weight, cables or other mine equipment.



The Collar is the area surrounding the shaft opening at the face of the mine.

The Shaft Lining is the sides of the shaft. It is made of timber, steel or cement.

Shaft Guides keep the conveyance in proper position. Vertical shafts have fixed guides made of wood timbers or steel rails or rope guides of locked coil ropes. Slope shafts have tracks to guide the conveyance and rollers to guide the rope.

A Landing or Station is the opening of a level onto the shaft.

A Safety Gate is the guard across a landing of the shaft.

The Dump is the area where the conveyance empties its load of coal or ore.

Utility Pipes and Cables are the paths for power, water, air and communications. They enter the mine through the shaft.

Unit 8

CONVEYANCES

A conveyance is a platform that carries men and equipment to the working levels of the mine, and carries men, equipment, and ore and muck tot the surface.

In a shaft mine there are two basic kinds of conveyance:

- cage—to carry men and equipment
- skip—to carry ore, waste, and some heavy equipment.

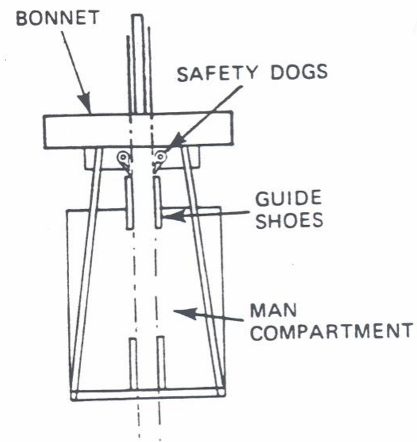


Figure 1

The parts of a cage are: (See Figure 1)

The man compartment is the protected enclosure that the men ride in.

The bonnet protects the man compartment from falling objects

The safety dog is an emergency braking device that is attached to the conveyance. A typical safety dog is shown in Figure 2.

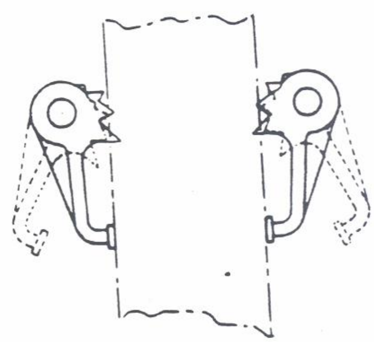


Figure 2

The safety dog is activated by a spring if slack appears in the hoist rope. When activated, the safety dog digs into the shaft guides, bringing the conveyance to a stop.

The guide shoe is the part of the conveyance that travels along the shaft guide. The guide shoe prevents the conveyance from moving horizontally in the shaft.

A skip is designed to dump its contents by:

- turning upside down, or
- opening its bottom or lower side.

Emergency Braking Device

The parts of an upside-down dumping skip are: (See Figure 3)

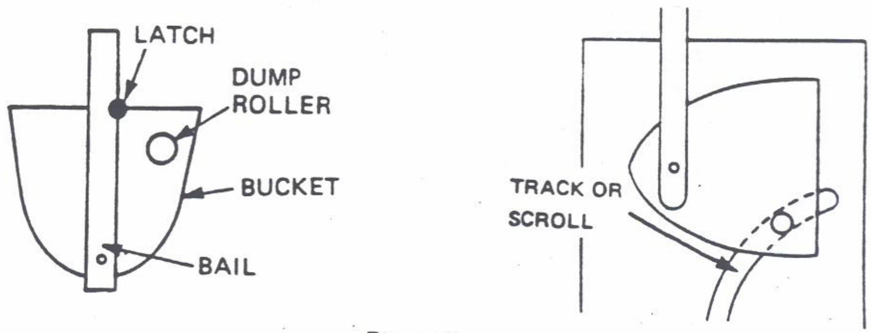


Figure 3

The dump roller is a wheel or roller mounted on the side of the conveyance.

The bail is the framework that supports the skip.

The bucket is the container for the ore, waste or heavy equipment.

The latch holds the skip upright.

The track or scroll engages the dump roller and dumps the skip.

A skip that dumps its contents by opening its bottom or lower side is called a bottom-dump skip. The parts of a bottom-dump skip are: (See Figure 4)

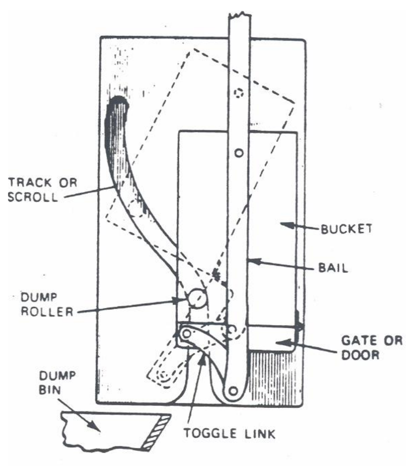


Figure 4

The gate or door is the side or bottom that opens to let ore out.

The actuating mechanism is the linkage that causes the gate to open. It includes the dump roller, and the track or scroll.

The bail is the framework that supports the skip.

The bucket is the container for the ore, waste and heavy equipment.

The safety latch is the device which prevents the gate from opening accidentally. It is actuated by the toggle link as the dump roller enters the scroll.

As the skip nears the dump point, the dump roller follows along a track or scroll. The shape of the track or scroll causes the roller to move horizontally and turn the skip upside down or open the skip dump gates.

Some conveyances are combinations of a skip and a cage. These combinations may look like: (See Figure 5)

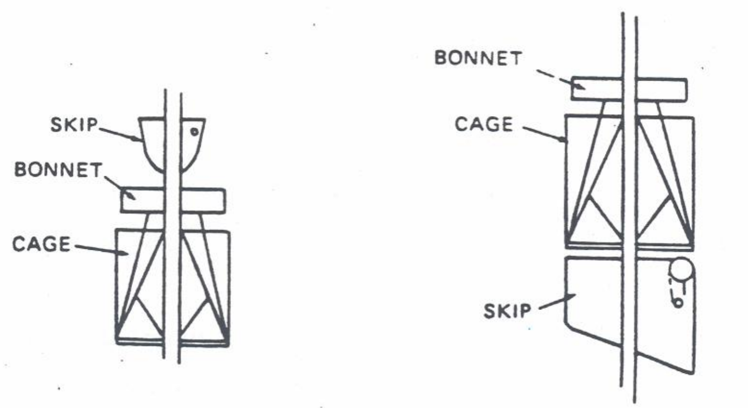
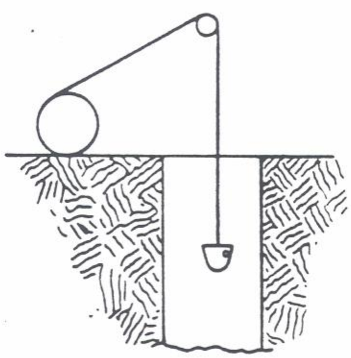


Figure 5

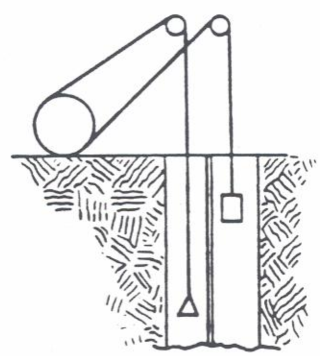
A vertical shaft hoist may have:

- a single rope and single conveyance. (See Figure 6)
- two ropes with a conveyance and a counterweight. (See Figure 7)
- two ropes with two conveyances. (See Figure 8)



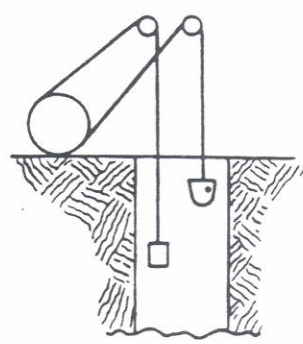
SKIP

Figure 6



SKIP-COUNTERWEIGHT

Figure 7



SKIP-CAGE

Figure 8

A tailrope may be connected to the bottom of the conveyances or conveyance and counterweight to balance the weight of the hoist rope. (See Figure 9)

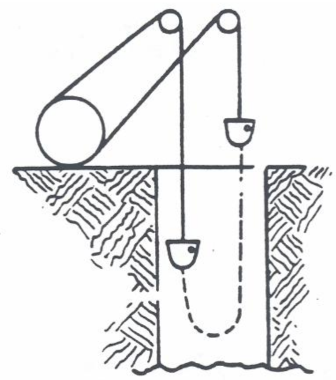


Figure 9

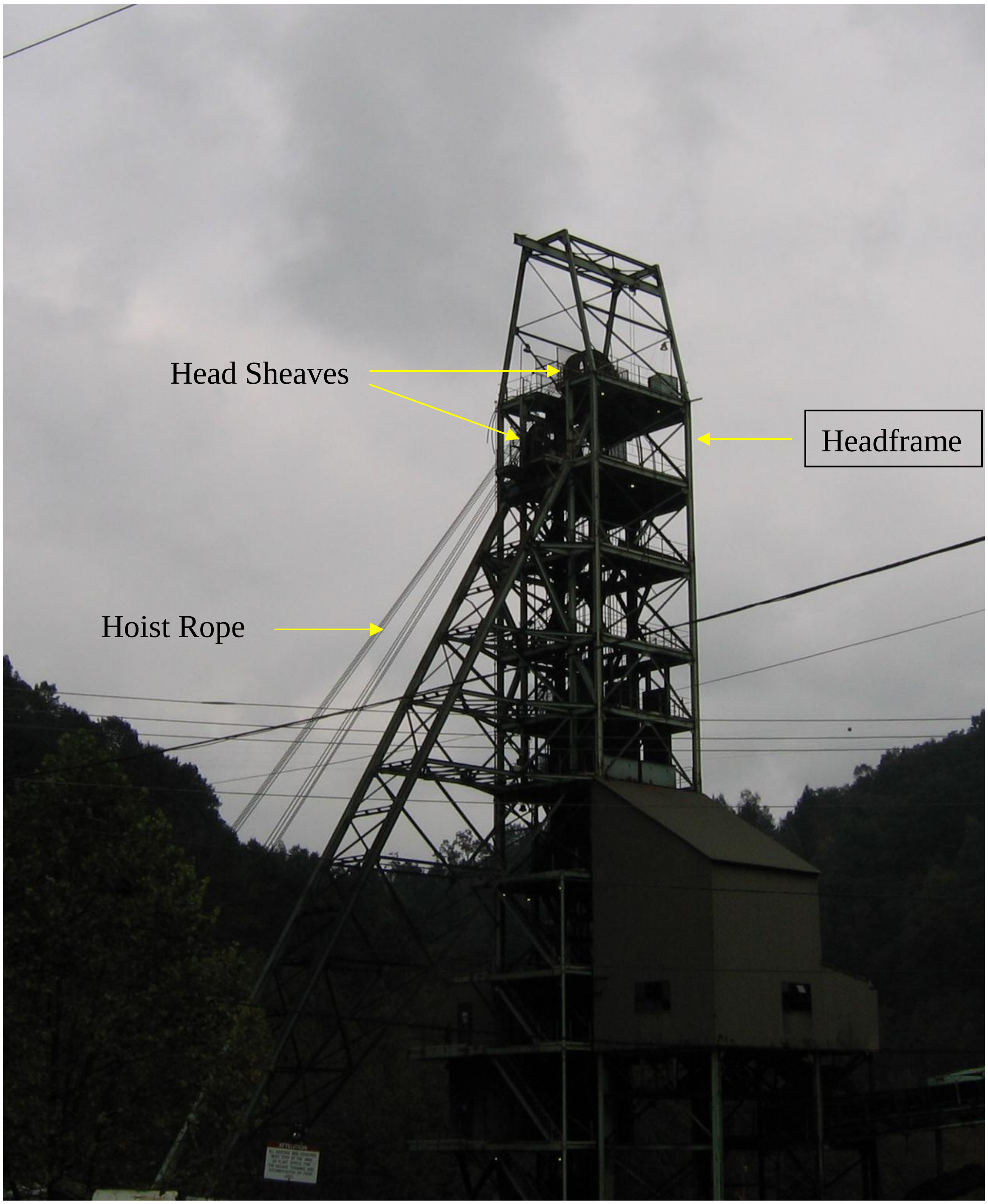
In a slope mine there are also two basic kinds of conveyance:

- man cars—to carry men and equipment.   man cars are fitted with seats.
- ore cars—to carry ore, waste and some heavy equipment. Ore cars can be dumped by turning them upside down or by opening the bottom. (See Figure 10)

Figure 10

Safety dogs are provided to stop the car if he rope breaks or goes slack. The dogs are forced into the ground by a spring. Magnetic brake cars may also be used to stop the man car if the rope breaks. They are down slope from the man car and apply brakes through magnets.

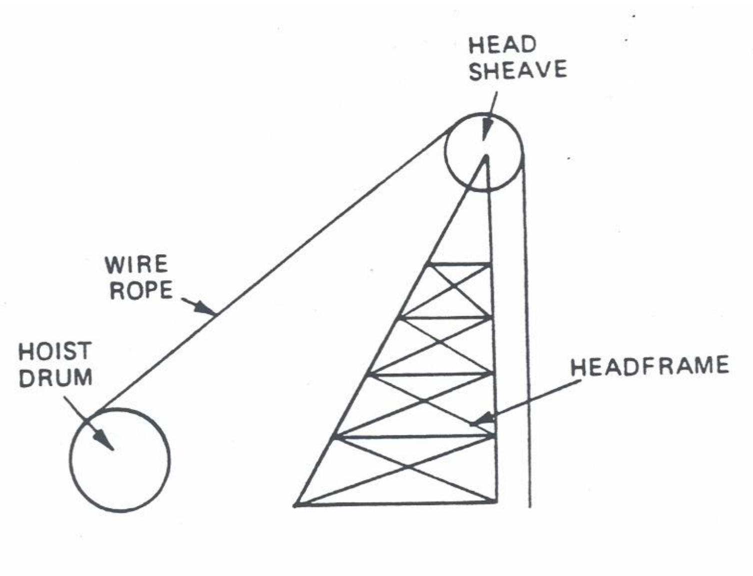
Unit 9
HEADFRAME



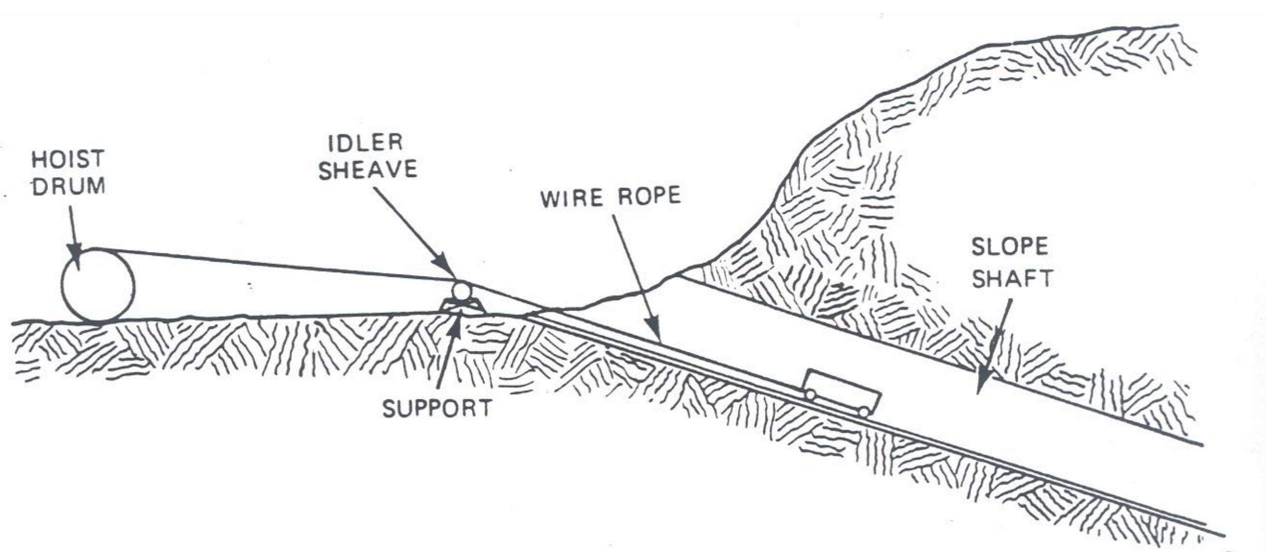
The Headframe supports the headsheave or head (Koepe) wheel over a shaft.

The headframe for a drum hoist holds a headsheave which supports the hoist rope.

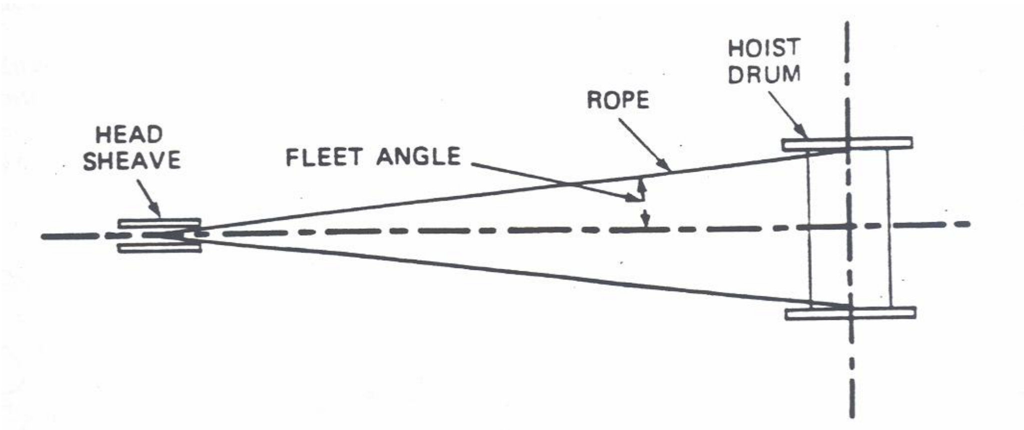
In a vertical shaft it looks like this:



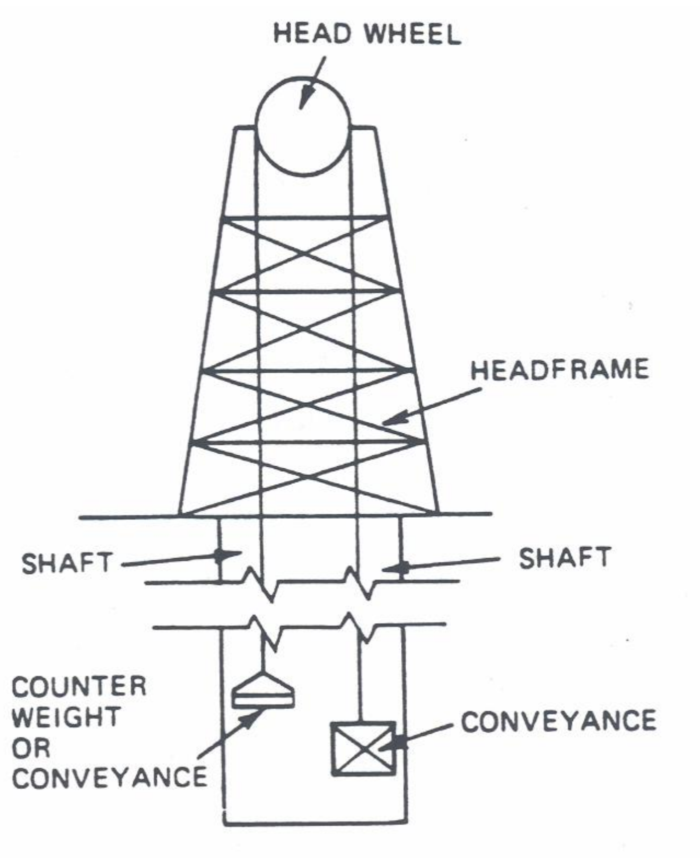
In a slope shaft an idle sheave and support replace the headsheave and headframe.



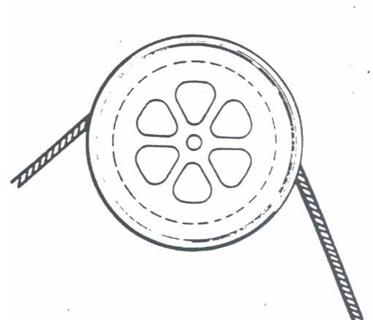
The angle between the center line of the sheave and the hoist rope is called the Fleet Angel. The fleet angle must not be more than 1 1/2 degrees for smooth drums or 2 degrees for grooved drums or excessive wear on the rope will result.



The Headframe for Koepe or friction hoist may support the wheel and drive motor.



Unit 10
SHEAVES



SHEAVES

A sheave is a grooved wheel which supports the hoist rope. Thee are three kinds of sheaves:

- An idler sheave which supports a long length of the rope. (See Figure 1)
- A knuckle or curve sheave which supports the rope where it changes direction. (See Figure 2_
- A head sheave which supports the rope and the conveyance at the head of the shaft. (See Figure 3)

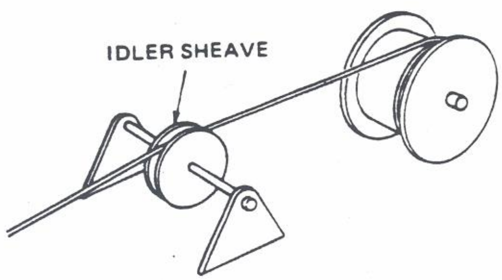


Figure 1

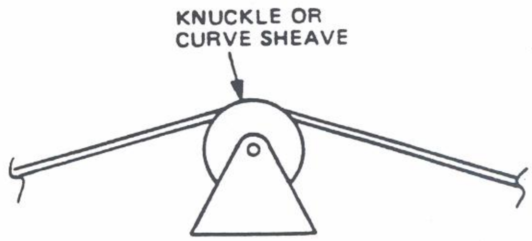


Figure 2

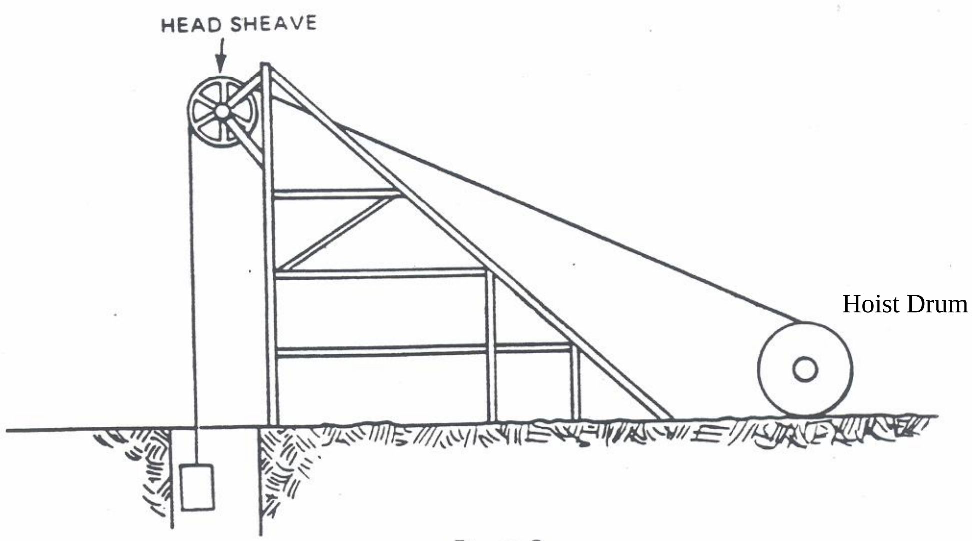


Figure 3

The critical features of a sheave are: (See Figure 4)

- groove
- diameter

The <u>groove</u> is the part of the sheave that the hoist rope rest on. The size of the groove must be fitted to the size of the rope. (See Figure 5)

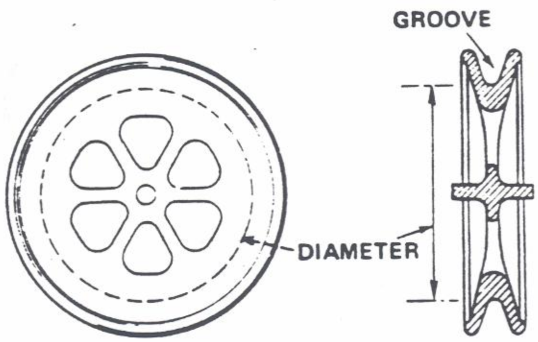


Figure 4

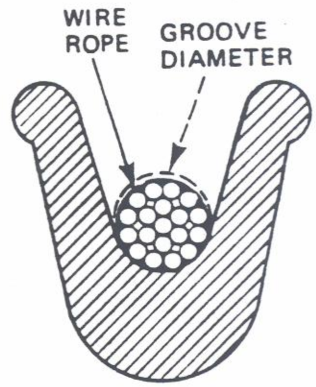


Figure 5

Too large a groove will tend to flatten the rope and cause the rope to weaken. (See Figure 6)

Too small a groove will squeeze, distort and damage the rope as well as damage the groove. (See Figure 7)

In order to save the high replacement cost of a worn sheave, liners of wear-resistant metal are used. (See Figure 8)

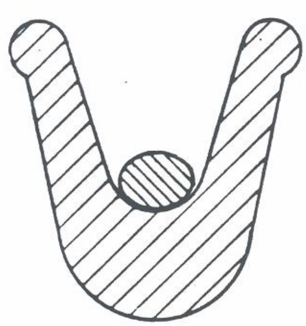


Figure 6

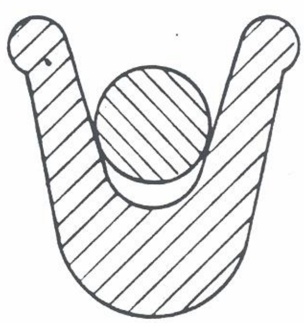


Figure 7

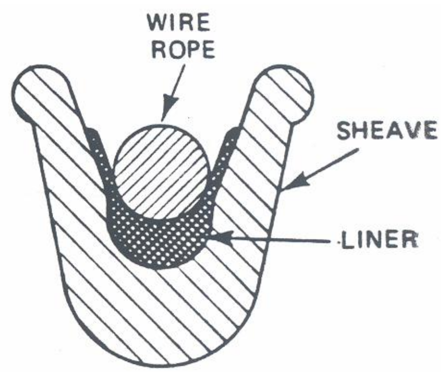


Figure 8

The size of a sheave is described by its diameter. (See Figure 4)

The diameter of the sheave must be suited to the diameter of the rope. Too small a sheave diameter will cause too sharp a bend in the rope and will damage the rope. (See Figure 9)

For the average mine hoist rope, the manufacturers recommend that the sheave diameter be 45 or more times the rope diameter. Little or no wear occurs if he sheave diameter is 90 times the rope diameter. (See Figure 10)

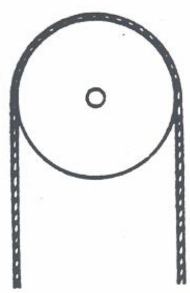


Figure 9

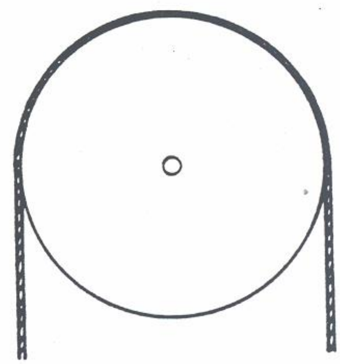


Figure 10

REGULATIONS

Metal and Nonmetallic Mines

Head, idler, knuckle and curve sheaves shall have grooves that support the ropes properly. Before installing new ropes, the groves should be inspected and where necessary machined to the proper contour and the proper groove diameter.

Sheaves shall be inspected daily and kept properly lubricated.

Coal Mines

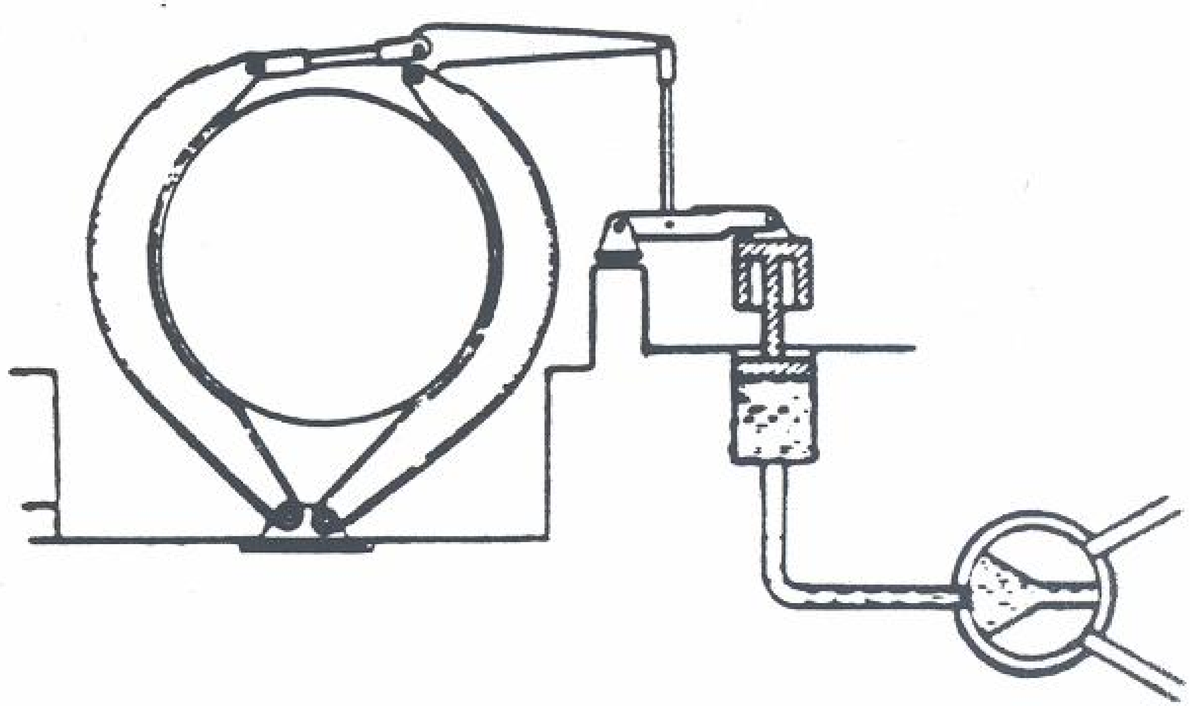
DAILY EXAMINATION OF HOISTING EQUIPMENT

The daily examination of hoisting equipment shall include:

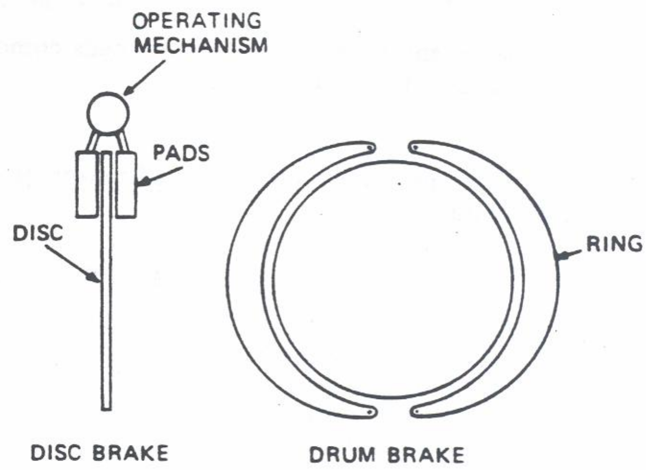
- an examination of the head sheaves to check for broken flanges, defective bearing, rope alignment, and proper lubrication.

Unit 11

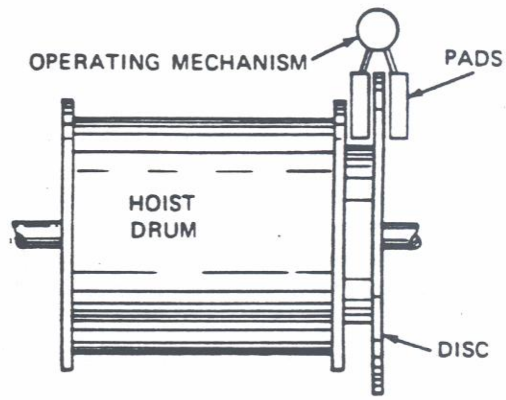
BRAKE SYSTEM



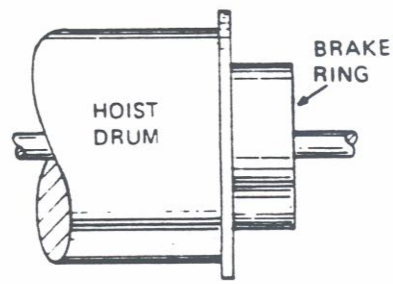
Brakes stop the hoist drum and hold it in one position. There are two types of brakes: disc and ring or drum brakes.



The Disc Brake is connected to the hoist drum like this:

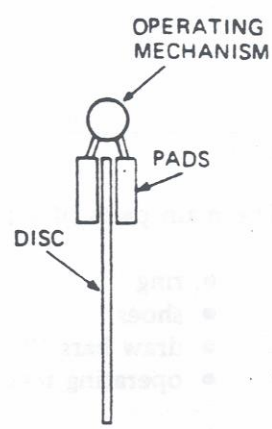


The Ring Brake is connected to the hoist drum like this:

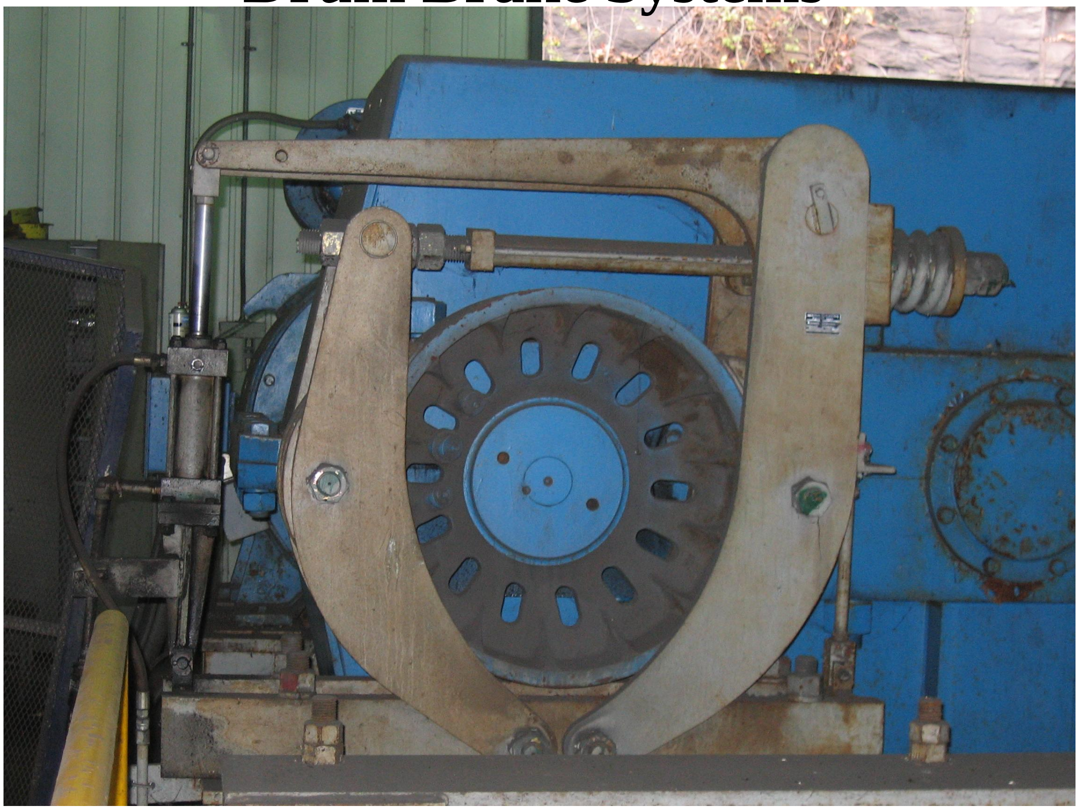


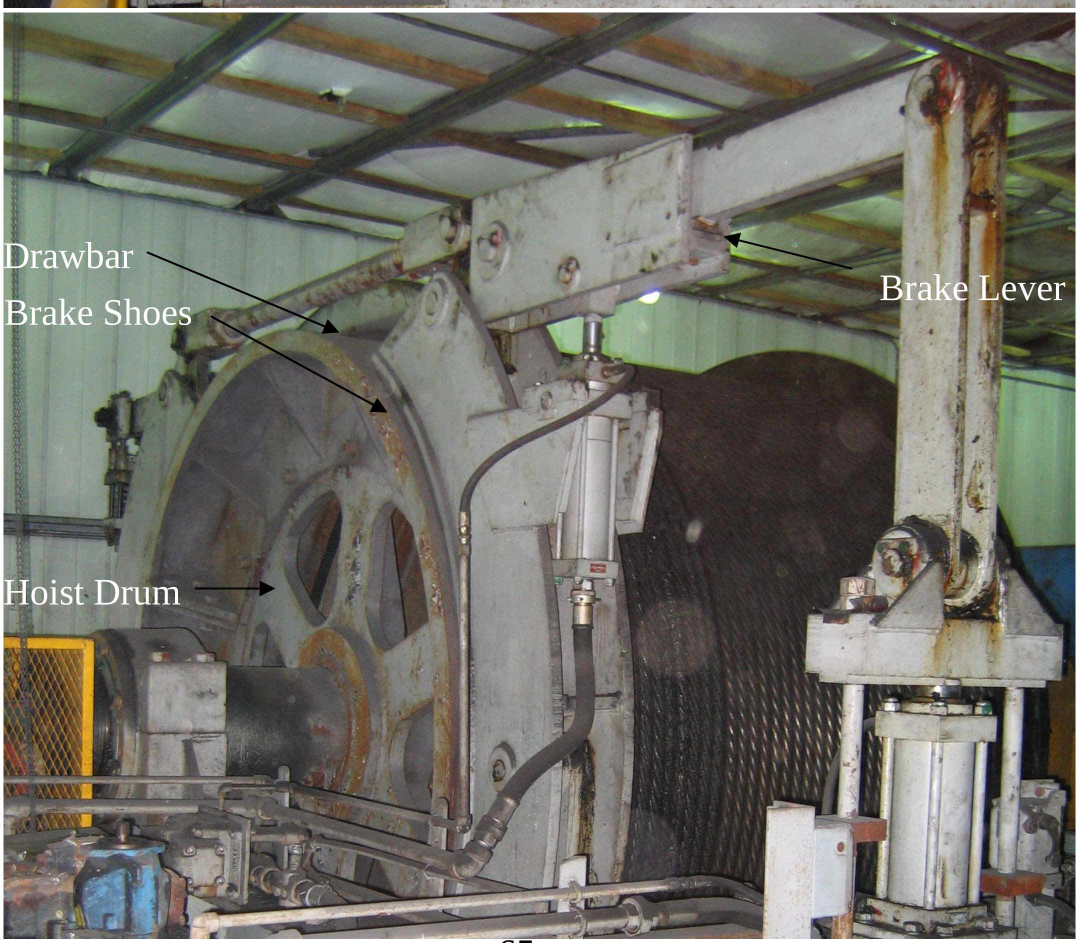
The main parts of a Disc Brake are:

- disc
- pads
- operating mechanism

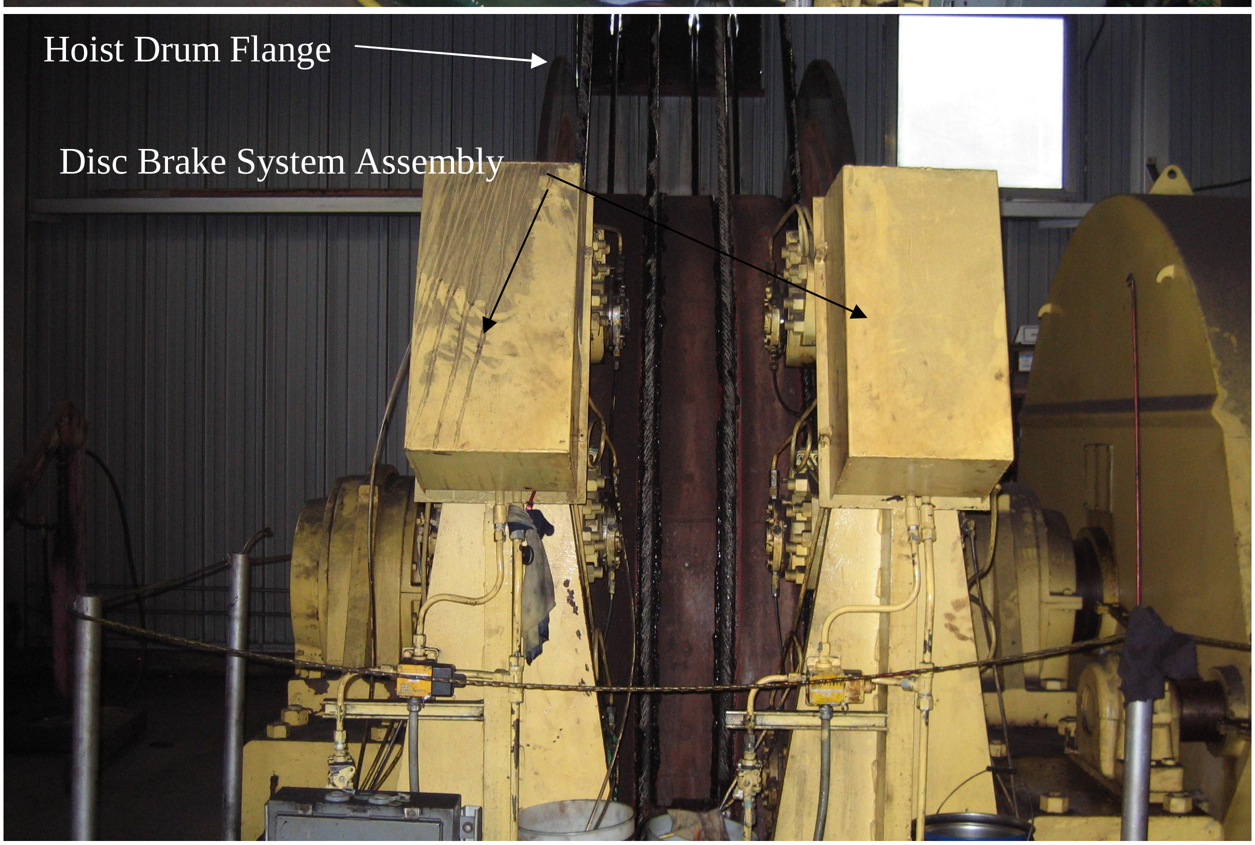


Drum Brake Systems





Disc Brake System

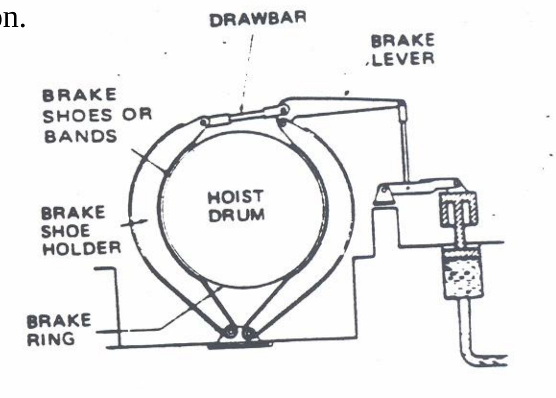


When the brake is applied the pads come together to press against the disc. This pressure prevents the disc from moving.

There are two types of Ring Brakes: jaw and parallel motion.

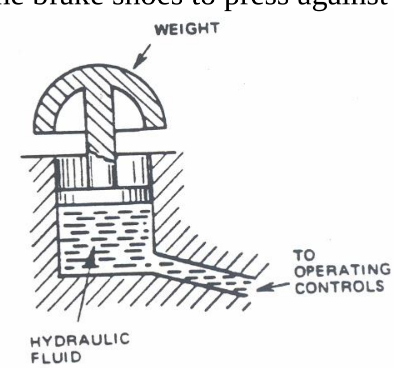
The main parts of a Jaw Brake are:

- ring
- shoes or bands
- draw bar
- operating mechanism



JAW BRAKE

The brakes are operated by a combination of hydraulic and/or pneumatic pressure and gravity or by hand through a system of levers. To apply the brakes, the hydraulic pressure on the cylinder is released. The weight can then pull down on the brake lever which by pulling on the drew bar brings the brake shoe holders together. This action causes the brake shoes to press against the ring.

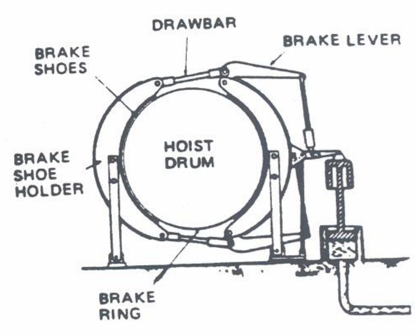


To release the brake, hydraulic pressure is restored to the cylinder. The weight is lifted, and moves the brake lever upward. This action allows the brake shoe holders to separate and lift the brake shoes from the brake ring.

A Parallel Motion Brake is similar to a jaw brake.

The main parts of a parallel motion brake are:

- ring
- shoes
- draw bars (2)
- operating mechanism



Theses brakes are also operated by gravity. The weight pulls on both brake levers and trough the draw bars and the brake shoe holders presses the shoes against the ring.

Any hoist used to hoist men shall be equipped with a brake or brakes which shall be capable of holding its fully loaded cage, skip or bucket at any point in the shaft.

The operating mechanism of the clutch of every man-hoist drum shall be provided with a locking mechanism, or interlocked electrically or mechanically with the brake to prevent accidental withdrawal of the clutch.

Automatic hoists shall be provided with devices that automatically apply the brakes in the event of power failure.

HOISTS: BRAKES, CAPABILITY

Brakes on hoists used to transport persons shall be capable of stopping and holding the fully loaded platform, cage or other device at any point in the shaft, slope or incline.

Unit 12

CLUTCH

The clutch is the device which engages or disengages the drum from the hoist motor. There are two basic types of clutch: the tooth or positive engagement clutch and the friction clutch.

The parts of the tooth or positive engagement clutch are : (See Figure 1)

- clutch spider
- clutch ring
- operating mechanism

The clutch spider is keyed to the hoist drum shaft.

The clutch ring is fastened to the hoist drum frame.

The arms of the spider have grooves or teeth that match those on the clutch ring.

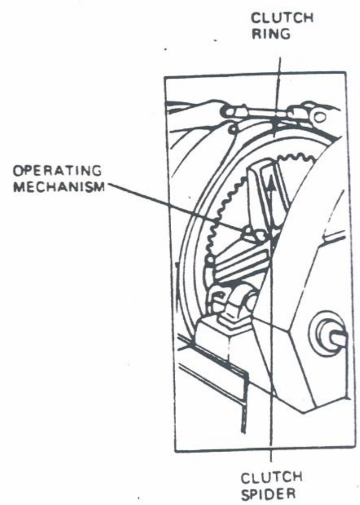


Figure 1

The operating mechanism moves the clutch spider away from or toward the clutch ring. This operating mechanism may be hydraulically or pneumatically powered.

When the clutch spider is against the clutch ring, the teeth on the spider engage with the teeth of the ring. If the drum shaft rotates, the clutch spider rotates and causes the drum to rotate.

When the clutch spider is moved away from the clutch ring, the teeth disengage and the clutch is disengaged. The shaft can then turn independently of the drum.

Some hoists have a friction or band clutch. (See Figure 2)

The parts of a friction clutch are:

- clutch ring
- clutch spider
- bands
- friction blocks
- operating mechanism

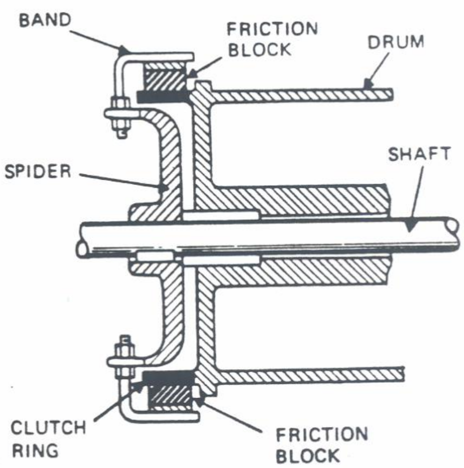


Figure 2

The <u>clutch ring</u> is fastened to the hoist drum frame.

The <u>clutch spider</u> is keyed to the hoist drum shaft.

The spider has a <u>band</u> on the end of each arm which supports a friction block.

> To engage the clutch, the operating mechanism causes the friction blocks to press against the clutch ring.
>
> Friction between the friction blocks and the ring causes the ring and the attached drum to rotate with the shaft.
>
> To disengage the clutch, the friction blocks are pulled away from the clutch ring.

The hoist is equipped with a clutch brake interlock. This device requires that the brakes be applied to a drum before the clutch can be disengaged.

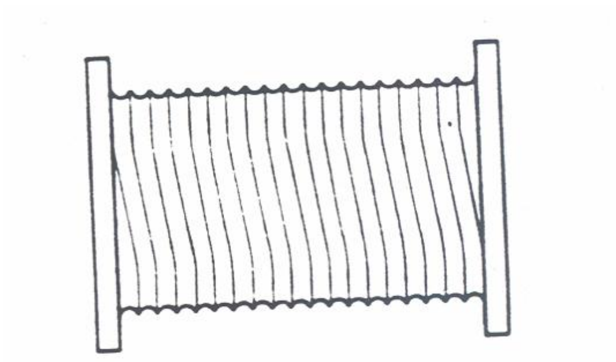
The operating mechanism of the clutch of every man hoist drum shall be provided with a locking mechanism, or interlocked electrically or mechanically with the brake to prevent accidental withdrawal of the clutch.

COAL MINES

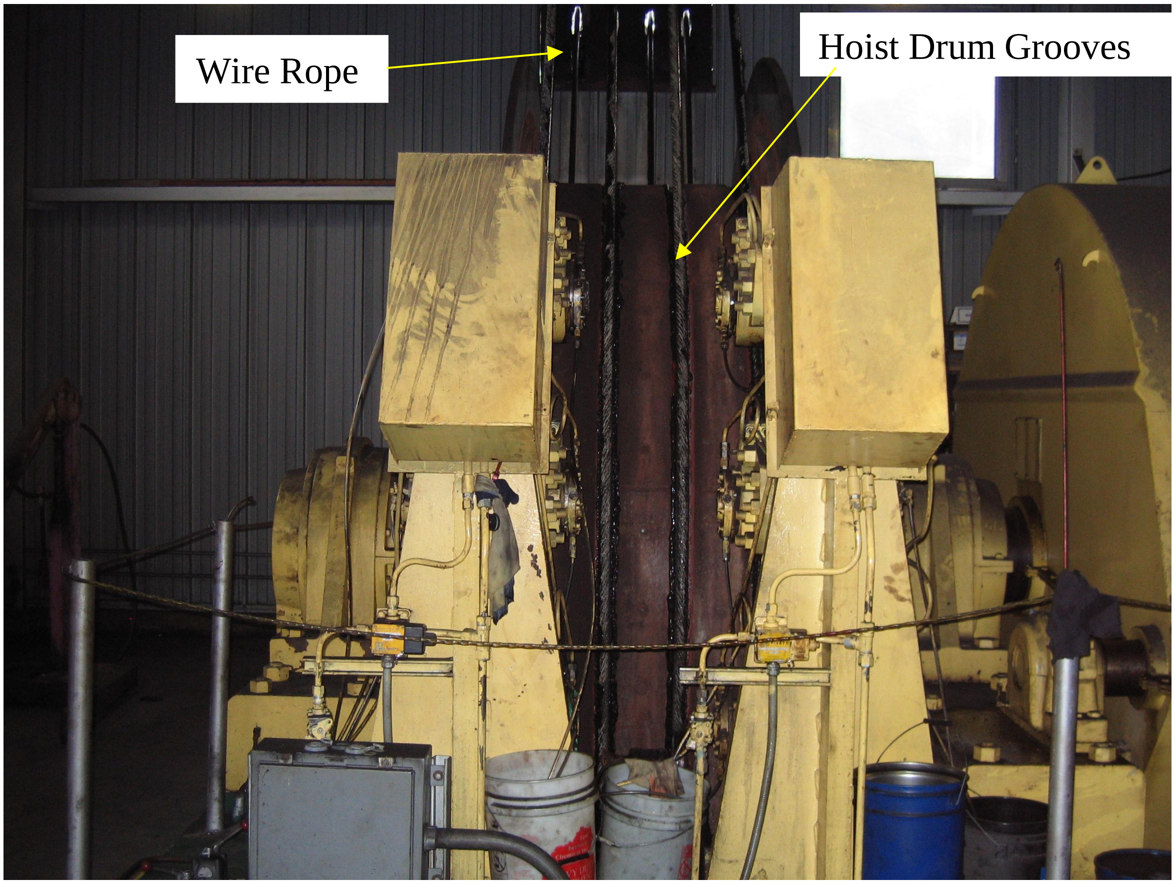
The clutch of free-drums on man-hoist shall be provided with a locking mechanism or interlocked with the brake to prevent the accidental withdrawal of the clutch.

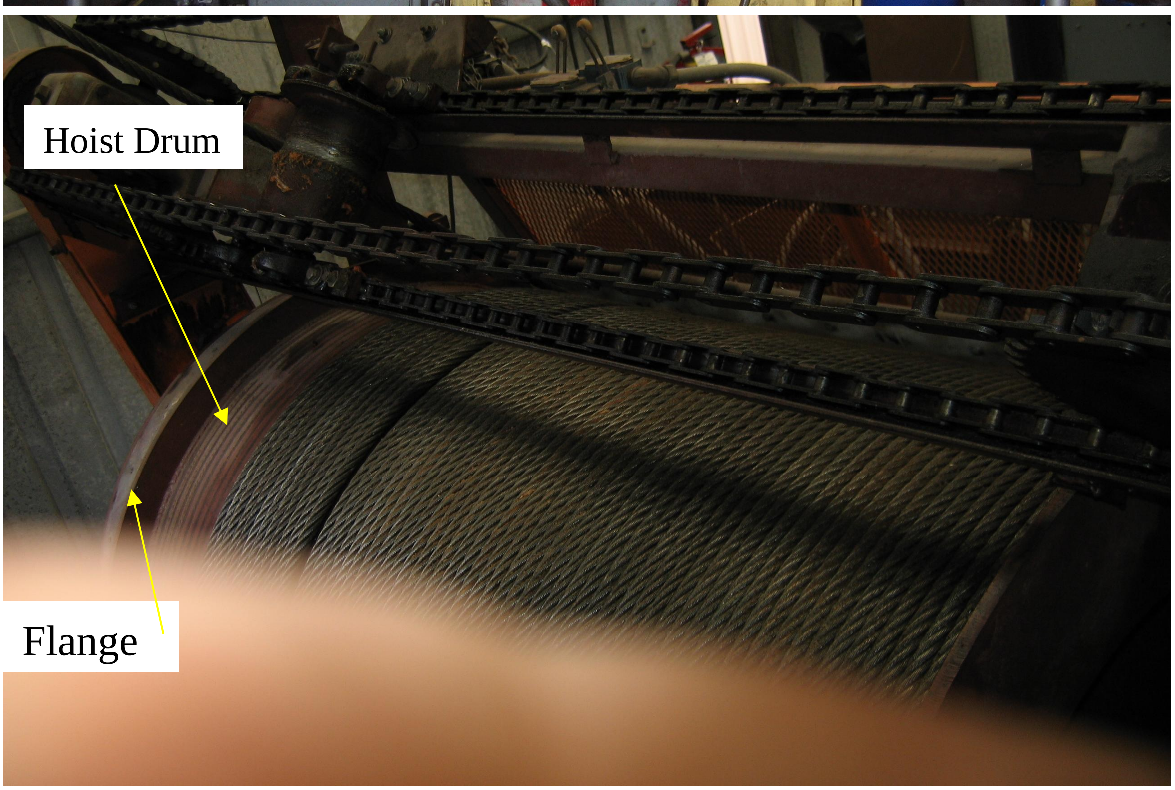
Unit 13

DRUM/WHEEL



Hoist Drum





HOIST DRUM OR WHEEL ASSEMBLY

The hoist assembly lowers and raises the hoist rope into and out of the mine.

There are two basic types of mine hoist assemblies:

- The Drum hoist in which the hoist rope is wound around a cylindrical drum and stored during the hoisting cycle;
- The Friction or Koepe wheel hoist in which the rope passes over the wheel during the hoisting process Friction between the rope and wheel moves the rope.

The drum and wheel are driven by a hoist motor through a gear train and drive shaft. Brakes are provided to slow, stop and hold the drum or wheel in a particular position.

The parts of a drum are: (See Figure 1)

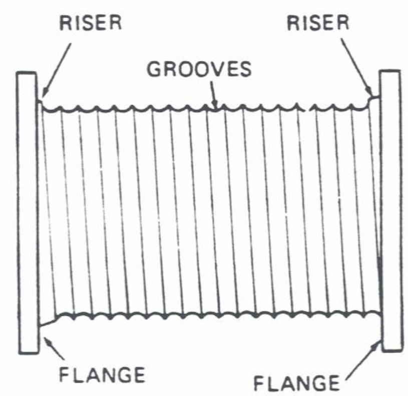


Figure 1

Flanges are the rims around the ends of the drum which present the rope from slipping off. Flanges must extend at least two rope diameters (minimum 4") beyond the last wrap.

Risers are metal strips that raise each successive rope layer as it winds at he ends of he drum.

A drum surface may be smooth or it may be grooved. Grooves are channels in the surface of the drum in which the rope lies. Grooves reduce wear on the hoist rope.

There are three types of grooves: (See Figure 2)

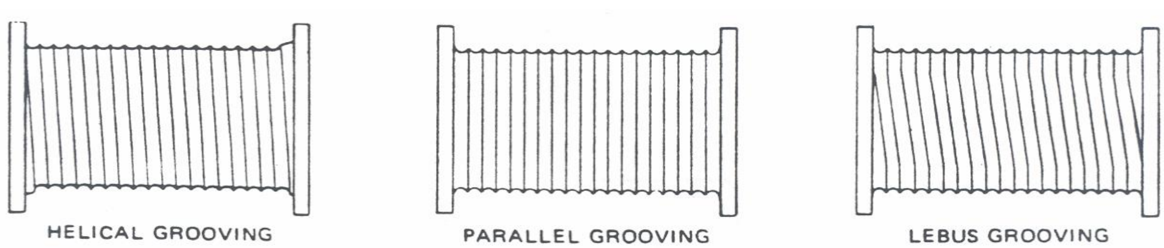


Figure 2

Helical grooving is a continuous spiral usually used for single layers or rope.

Parallel grooving is made up of evenly spaced grooves across the entire surface of he drum.

LeBus grooving is a combination of helical and parallel. One half turn is parallel and then the grooves become helical. This used for high-speed multi-level winding.

In a Friction or Koepe wheel hoist, the drum is replaced by a wheel. The wheel may be mounted on the headframe, where the headsheave is mounted on a drum hoist. Other hoist may have the Koepe wheel located in the hoist house in place of the regular drum.

The parts of a Koepe wheel are: (See Figure 3)

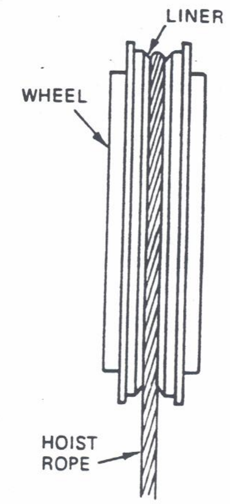


Figure 3

The liner provides a groove for the hoist rope to rest on.

The hoist assembly may take one of several forms.

Drum Hoist: Some drum hoist may have only one conveyance and no counterweight. There will be one drum and one rope. One end of the rope is attached to the conveyance, the other is attached to the drum. (See Figure 4)

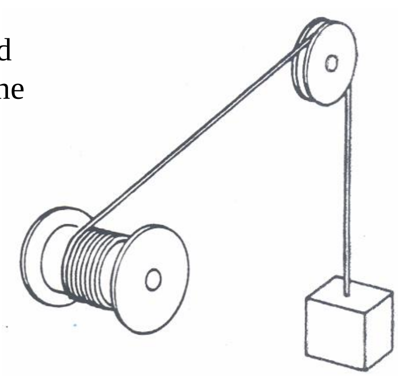


Figure 4

Other single drum hoists may have two conveyances or one conveyance and a counterwieght. The ends of the rope are attached to the conveyances or to the conveyance and counterweight. The rope makes several turns around the drum. As one end of the rope is wound onto the drum, its conveyance is hoisted while the other end of the rope is unwound from the drum and its conveyance or counterweight is lowered. (See Figure 5)

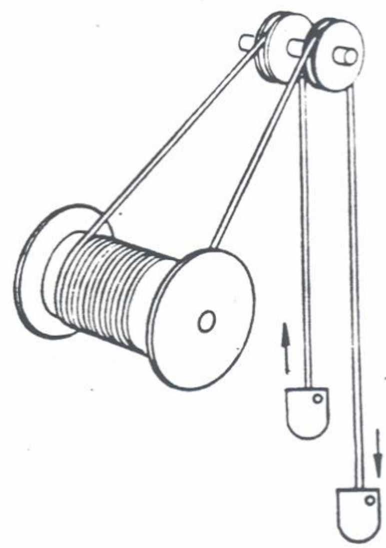


Figure 5

Some hoists have two drums on the same shaft; one rope is on each drum. One end of a rope is fastened to the drum and the other is fastened to the conveyance. The ropes are arranged so that when the rope on one drum is being wound, the rope on the other drum is being unwound. On most two drum hoists, a clutch is provided so that the drums can be operated separately. This clutch is particularly advantageous in a production hoist in a multi-level mine.

For example, when hauling ore from one level, one skip is at he dump unloading while the other skip is at he loading level being loaded. When the dumping and loading are completed, the loaded skip is raised to the dump while the empty skip is lowered to the loading level, and the unloading and loading operation are repeated. If the loading level is changed, one skip has to be moved on order for a skip to be at the dump while another is at he new loading level. (See Figure 6)

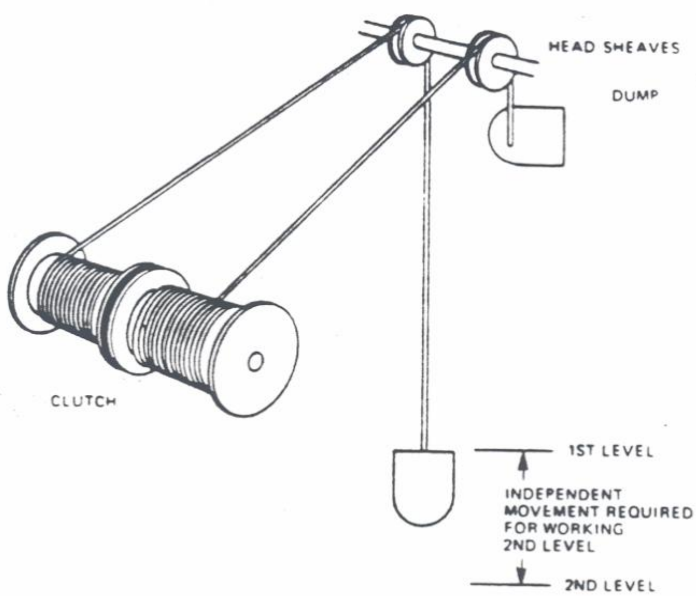


Figure 6

The Koepe Wheel or Friction hoist assembly is similar to the two conveyance one drum hoist, except that there is only one half turn of the hoist rope around the wheel. Several small ropes are normally used with the head (Koepe) wheel rather than on large rope. It is necessary that the length of each rope be equal so that the strain on each rope will be equal. (See Figure 7) Tail ropes are provided on friction hoists to compensate for the weight of the hoist ropes.

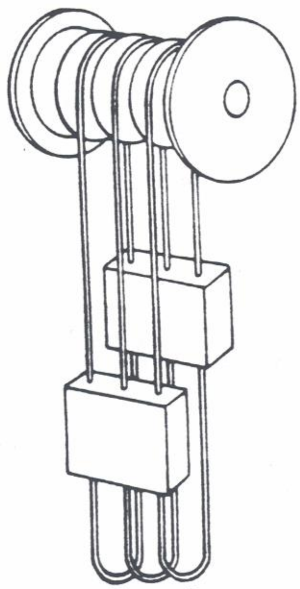


Figure 7

Flanges on drums shall extend radially a minimum of 3 rope diameters and not less than 4 inches beyond the last wrap.

Where grooved drums are used, the grooves shall be of suitable size and pitch for the rope used.

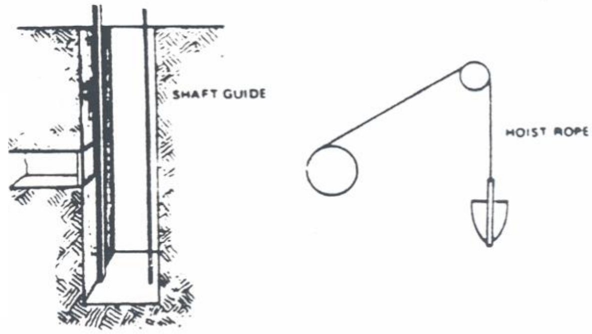
Unit 14

WIRE ROPE

The care, installation, maintenance and inspection of the hoist rope are engineering and/or maintenance functions. The hoist operator, however, is required to assist the responsible group. This unit will prepare the hoist operator to carry out his/her usual responsibilities. In mines where the hoist operator will be called upon to carry a heavier share of this load, he/she should receive further training. Many of the hoist rope manufacturers publish excellent texts which should be used for such training.

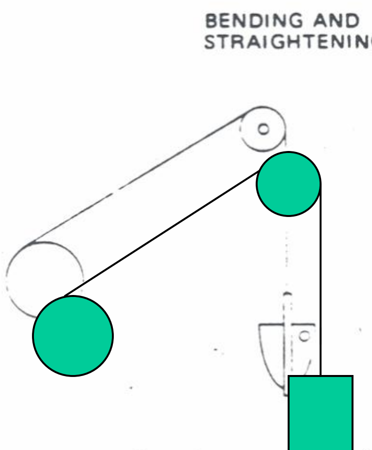
WIRE ROPE USE

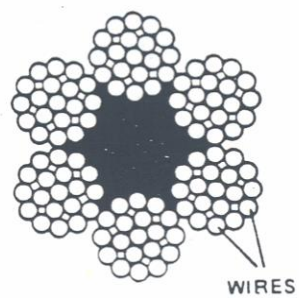
WIRE ROPE USE



Wire rope is used for the hoist rope, and in some mines, for shaft guides. It may also be used for guy wires for structures.

Wire rope that bends frequently while in use, the hoist rope for example, must be flexible. It is made up of many wires of small diameter.

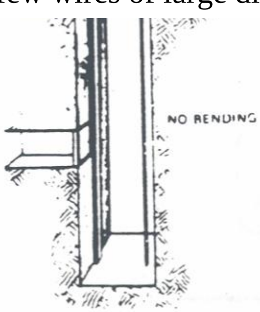


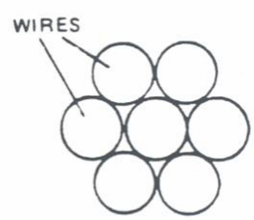


Typical Crossection

Wire rope that does not bend in use, shaft guides for example, need not be flexible.

Wire rope that does not bend in use, shaft guides for example, need not be flexible. It is made up of few wires of large diameter.



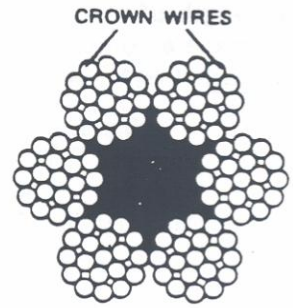


Typical Crossection

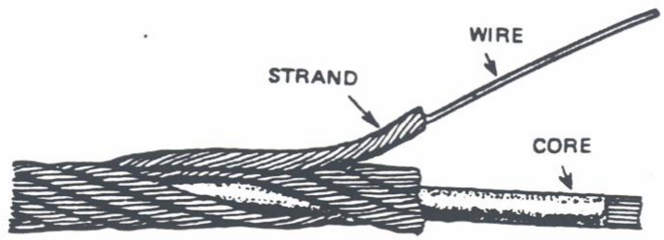
WIRE ROPE TERMS

There are three parts to a wire rope:

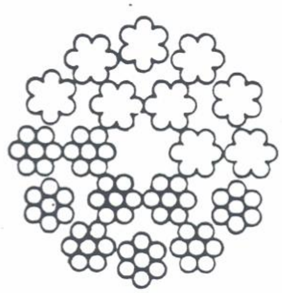
- •A <u>core</u> which forms the center of the rope
- •<u>Wires</u> which are twisted into strands. The wires which bear against a sheave or drum are called crown wires.
- •<u>Strands</u> which are twisted around the core into rope.



End View



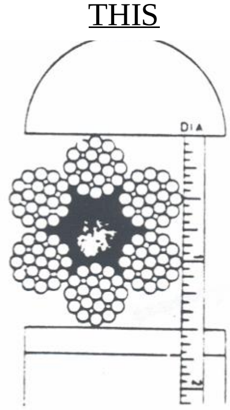
Rope is designated by the NUMBER OF STRANDS X THE NUMBER OF WIRES PER STRAND and ROPE DIAMETER.



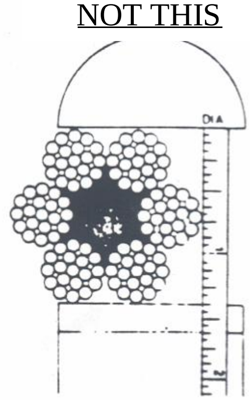
This rope has 18 strands of 7 wires each. It is an 18x7.

This rope has 6 strands of 19 wires each. It is a 6x19.

Rope diameter is measured like <u>THIS</u>



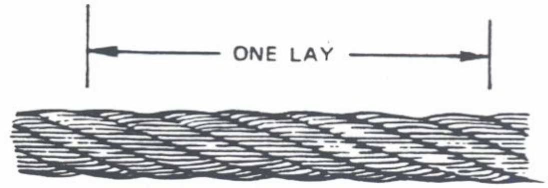
<u>NOT THIS</u>



This is a 1 1/2" Rope

Lay of rope

The length of rope that it takes for one strand to make a complete turn around the core is a Lay.



Right Lay

If the strands are twisted to the right, the rope is Right Lay..

RIGHT LAY

Left Lay

If the strands are twisted to the left, the rope is Left Lay.

LEFT LAY

Regular Lay

If the strands are twisted in on direction and the wires in the other direction, the rope is Regular Lay.

REGULAR LAY

Lang Lay

If the strands and wires are twisted in the same direction, the rope is Lang Lay.

LANG LAY

Safety Factor

The breaking strength of the rope divided by the load on the rope is the Safety Factor.

$$\text{Safety Factor} = \frac{\text{Breaking Strength}}{\text{Load}}$$

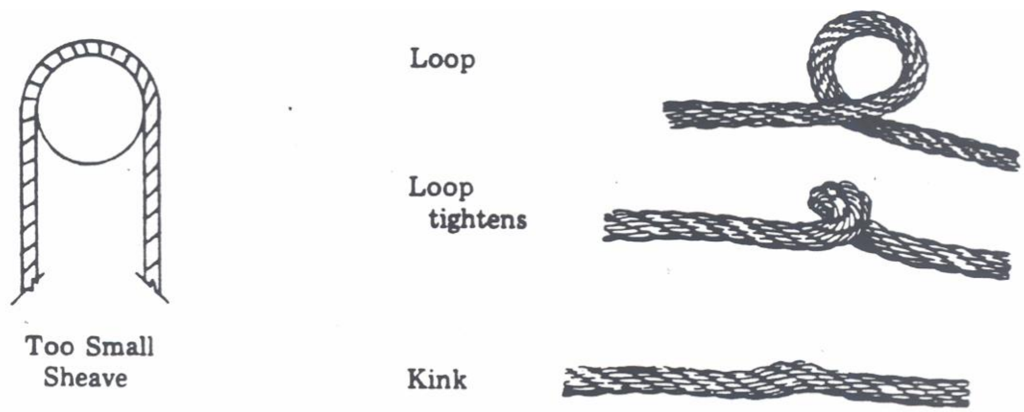
A rope with a 100,000 pound breaking strength carrying a normal load of 10,000 pounds has a Safety Factor of $\frac{100{,}000}{10{,}000}$ or 10.

WIRE ROPE CARE

Wire rope is expensive. Handle it carefully to prolong its life.

Avoid Sharp Bends

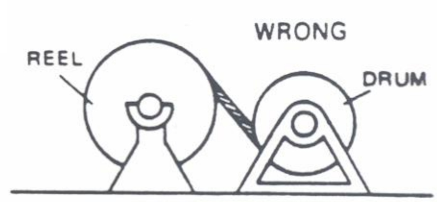
The use of too small a sheave or drum, or kinking will cause the wire rope to be weakened.



Avoid Reverse Bending

Avoid Reverse Bending

When transferring rope from Reel to Drum,

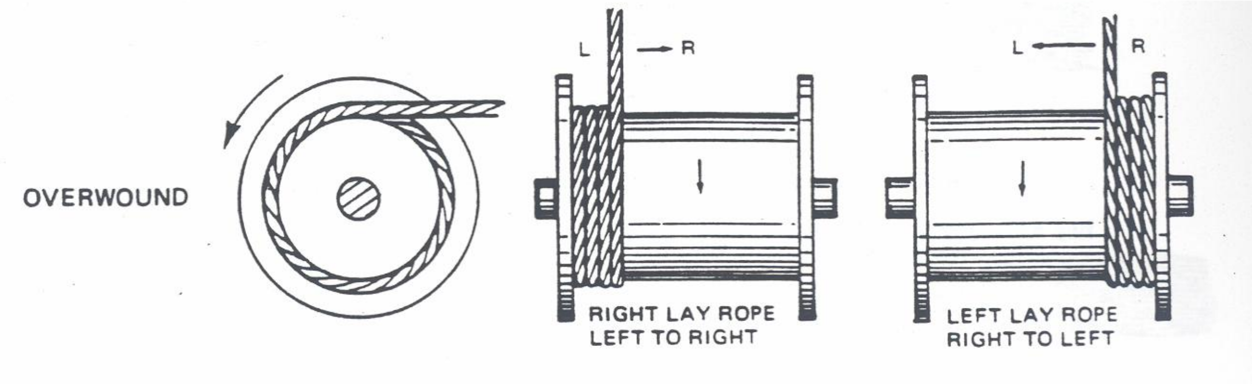


or in the rope run, reverse bending should be avoided.

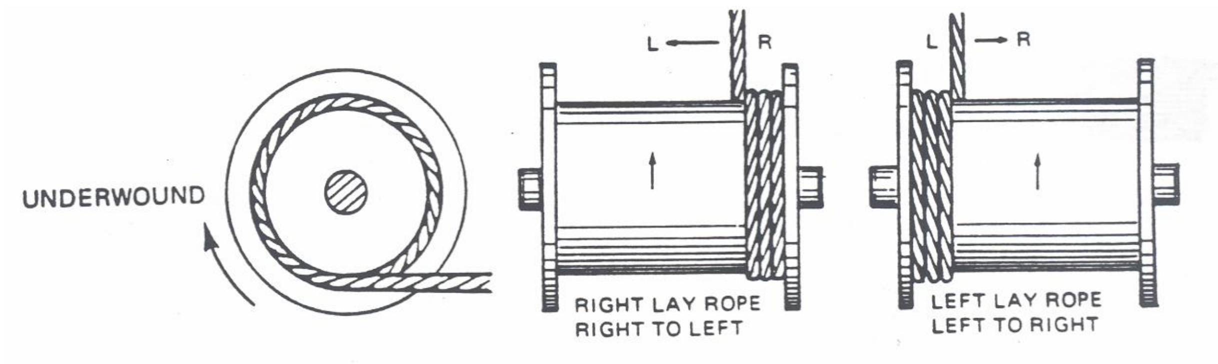
or in the rope run, reverse bending should be avoided.0

Use Proper Rope Lay

On Overwound drums start Right Lay from Left – Left Lay from Right.



On Underwound drums start Right Lay from Right – Left Lay from Left.



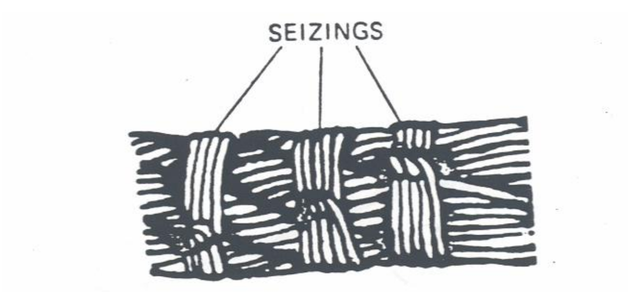
In all cases Use the Right Rope for the Job.

Cutting and Attaching Wire Rope

Wire rope is weakened if its shape or structure is changed. In cutting and attaching wire rope, the shape and structure is usually preserved by “seizing, “ that is, wrapping the rope with small wire.

Cutting

At least three seizing are made on each side of the planned cut.

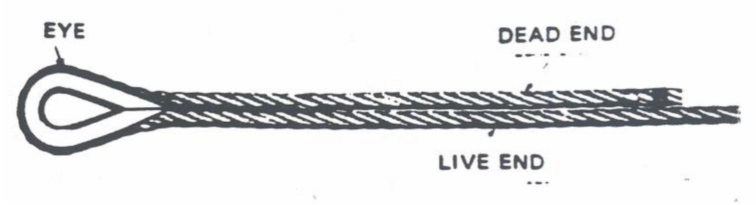


Attaching the Wire Rope

Normally an eye is put into the end of a wire rope to attach it to a drum, conveyance, counterweight or other object. A thimble is usually placed in the eye for support.

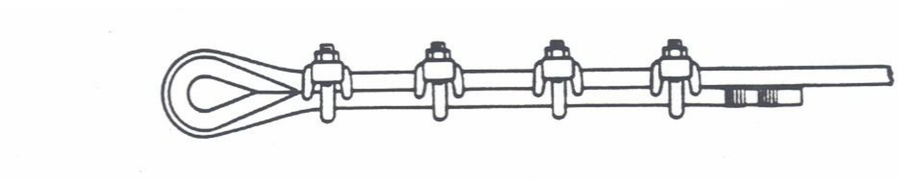
The long end of the rope is the live or working end.

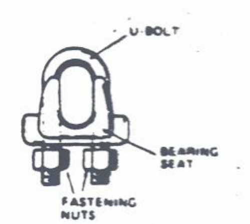
The short end is the dead or bitter end.



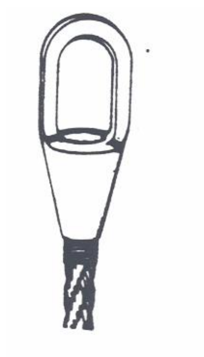
The eye can be put into the end of the rope with:

- U-Clips

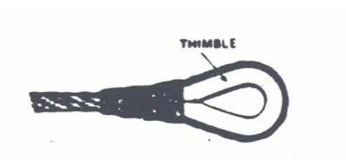




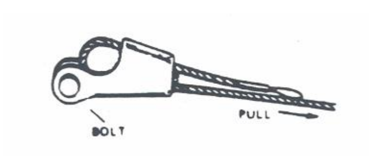
- A Socket



- An Eye Splice



- A Wedge Socket



U-Clips are often used because the process is simple and readily done by the average mechanic.

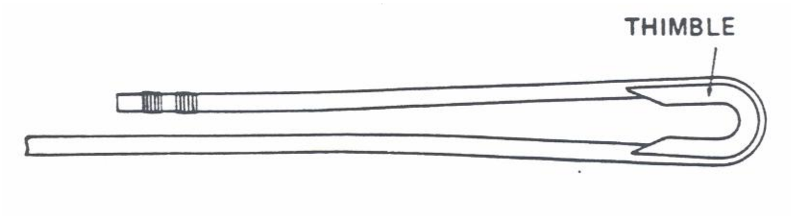
U-Clips

With U-CLIPS the Eye is formed in 5 steps:

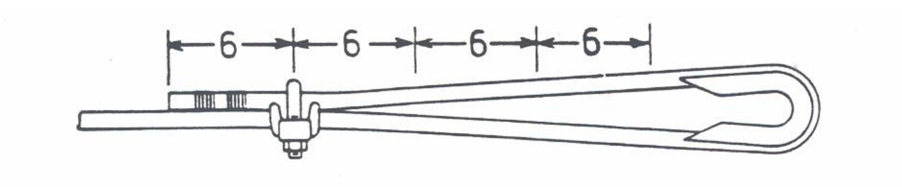
STEP 1 – Calculate the number of clips and slip spacing:

The Number of Clips (N) = 3 x Rope Diameter +1
For a 1” Rope: N = 3 x 1 + 1 = 4 clips required
Clip spacing = 6 x Rope Diameter
= 6 x 1 = 6 inches.

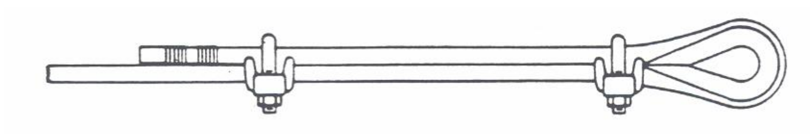
STEP 2 – Form the Eye around the Thimble.
The length of the dead end is equal to
Number of Clips X Clip Spacing = 4 X 6 = 24”



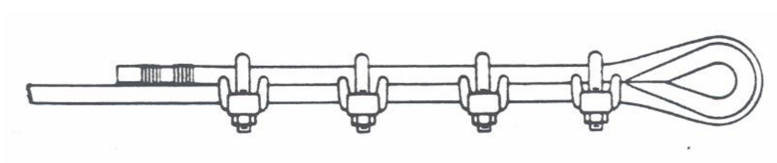
STEP 3 – Attach the U-Clip farthest from the Eye. Note that the U-Bolt touches the bitter end, NOT the working end.



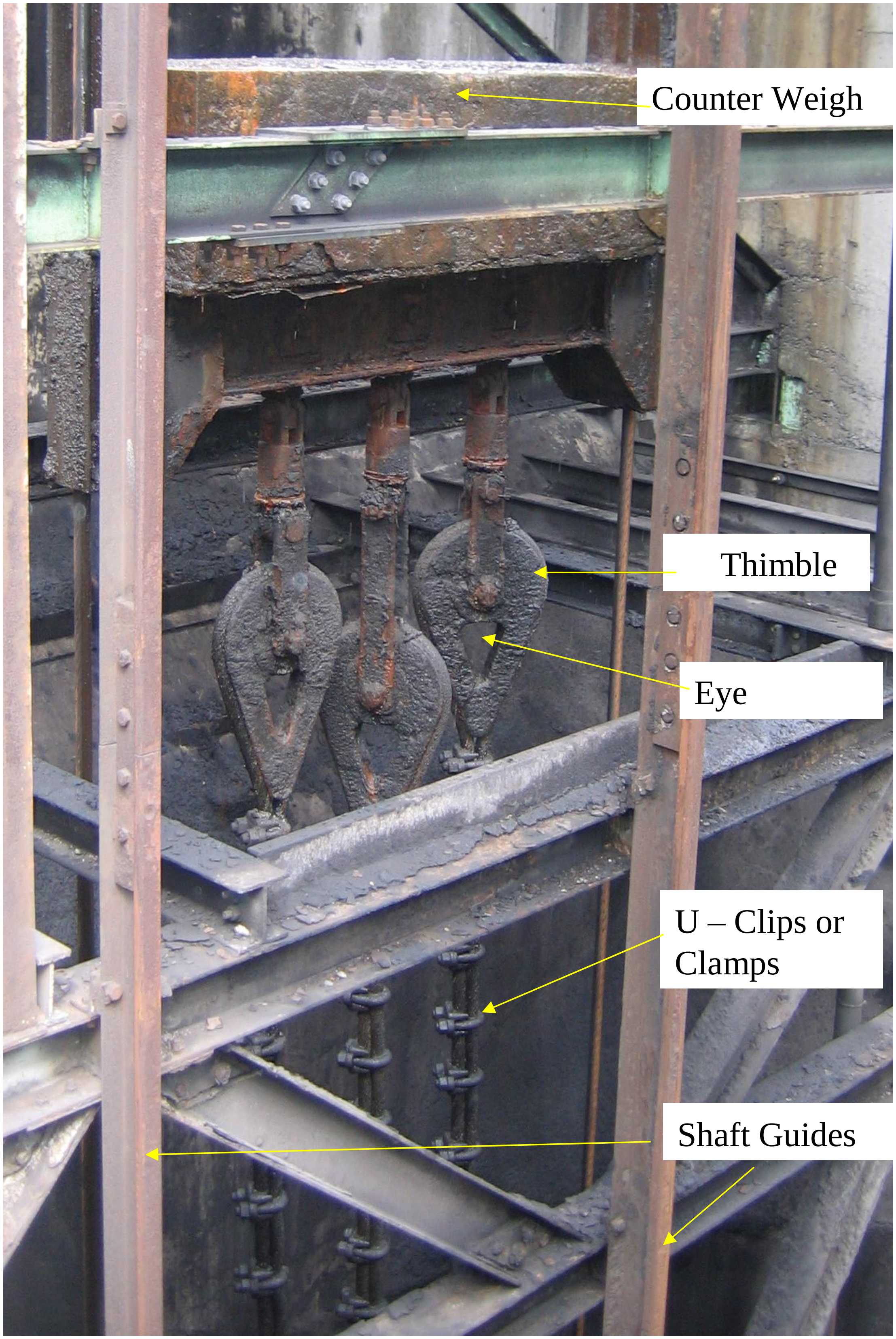
STEP 4 – Attach the U-clip nearest the Eye.



STEP 5 – Attach and tighten the remaining clips.



U-Clip Attachment

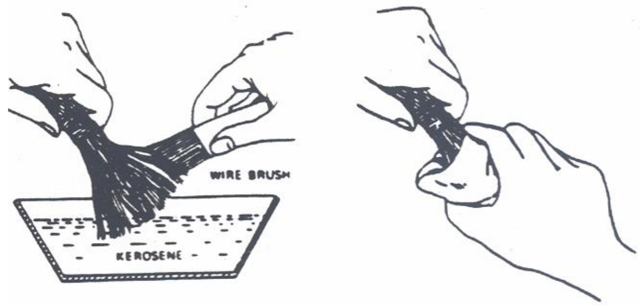


Socket

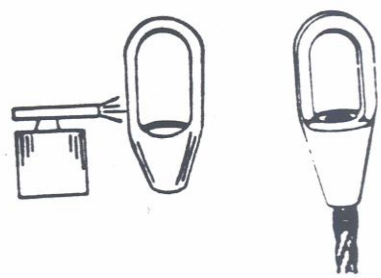
The Eye is formed with a Socket in 5 steps:

STEP 1 – Arrange the wires in the form of a brush down to the first seizing. I the rope has a non-metal core, remove the core down to the first seizing.

STEP 2 – Clean the “brush” with solvent (kerosene or similar); dry off solvent; dip ¾ of brush in muriatic acid, then clean brush with a soda mixture.

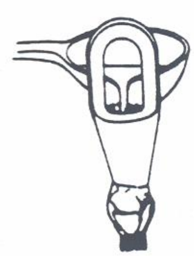


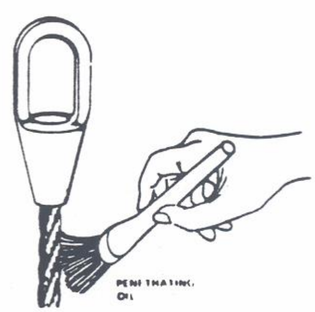
STEP 3 – Heat socket to 200º F, insert brush in socket; keep brush centered and perpendicular in the socket.



STEP 4 – Put fire clay or putty around the base of the socket and pour high grade Zinc (ASTM-SPEC. 8-6-58) heated from 850º to 1000º F into the socket.

Having the Zinc at the <u>RIGHT TEMPERATURE</u> is very important.



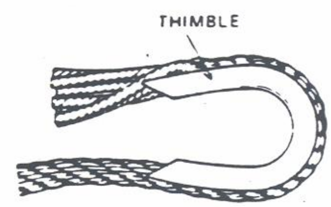


STEP 5 – Remove the fire clay and lubricate the rope up to the socket.

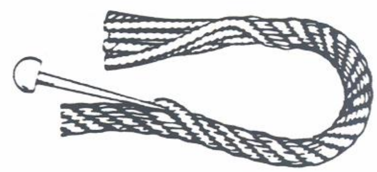
Eye splice

T EYE is formed with a Splice in 4 steps:

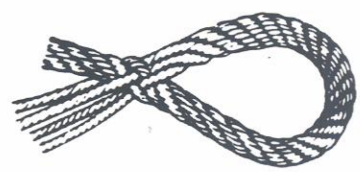
STEP 1 – Form the eye around the thimble about 1 lay from the dead end and separate the strands that extend beyond the thimble on the dead end.

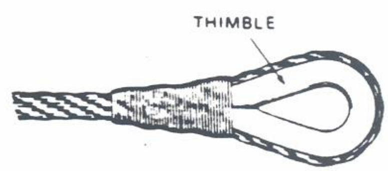


STEP 2 – Use a steel spike (MARLINSPIKE) to separate the strands on the working end.



STEP 3 – Interlace the strands from the dead end into the separations in the working end until each strand from the dead end has been laced over and under at least 3 times.





STEP 4 – Cover the spliced area with seizing wire.

Wedge Socket

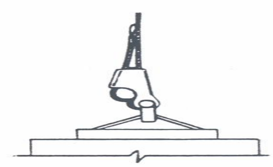
The Eye is formed with a Wedge Socket in 4 steps:

STEP 1 – Form a loop through the socket.

STEP 2 - Insert the wedge.

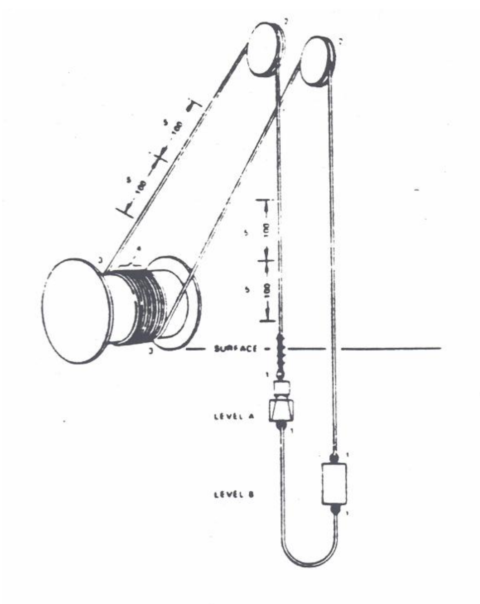
STEP 3 – Pull wedge and rope into position.

STEP 4 – Final tightening occurs under full load.



WIRE ROPE INSPECTION

Federal Regulations require that wire ropes used for hoisting shall be inspected regularly. Parts of the rope that require close inspection re:



1. Points where the rope is connected to the conveyance and drum:

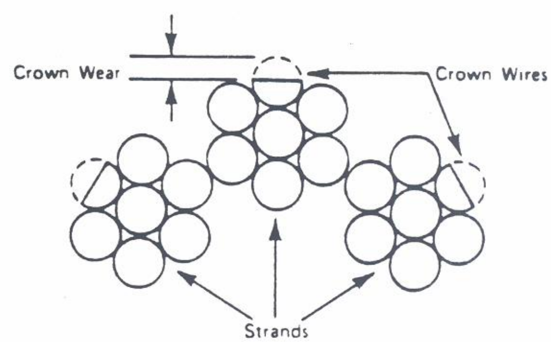
2. 3. & 4. Points where the rope leaves the sheaves or drums when the conveyance is at the loading levels or drum level;

5. Every 100 feet.

Defects that will require ropes to be removed from the hoist:

- Corrosion or distortion, as from a kink;
- Reduced wire rope diameter;

- 65% crown wear;



- More than 6 broken wires in one lay of rope;
- 30% crown wear and 3 broken wires in one lay;
- Dead rope; rope will not stretch under load.

Manufacturer's texts provide charts from which the ropes strength can be readily calculated if the number of broken wires in one LAY and "L", the length of wear on the crown wires, are know.

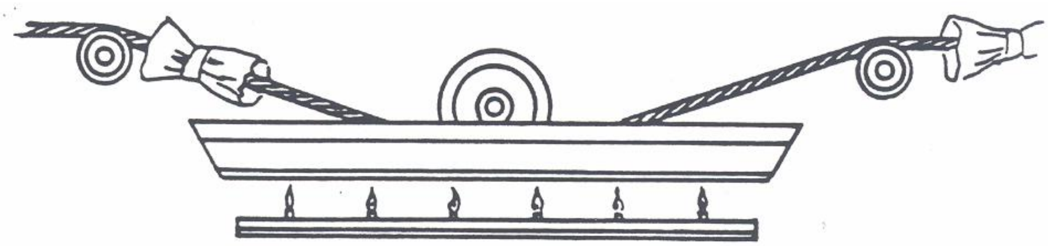
Inspection Process

The inspector will

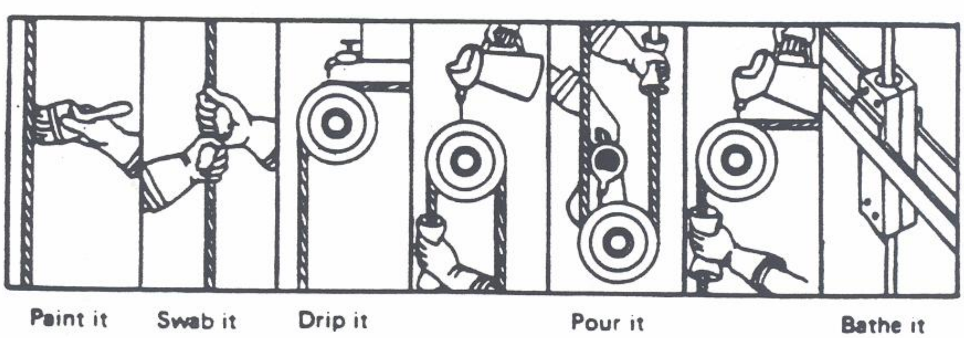
- Clean off a full lay of rope surface with solvent
- Measure and record the rope diameter
- Measure and record the length of crown wear
- Note and record the number of broken wires in that lay
- Move the conveyance until the next inspection point on the rope is at the inspection station.

LUBRICATION

Several methods of lubricating the wire rope are:



HEATED

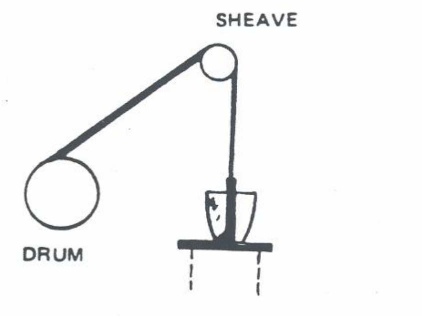


UNHEATED

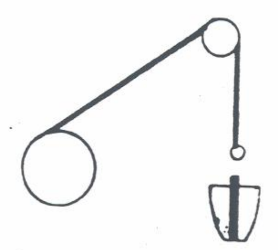
CHANGE THE HOIST ROPE

Specific procedures for changing the hoist rope vary depending upon the type of hoist, the space available in the immediate vicinity of the hoist and the collar, and the rewinding equipment available.

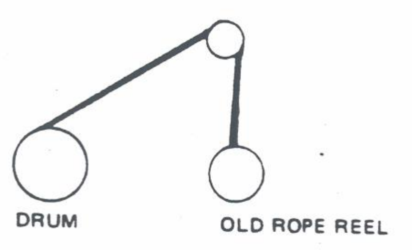
The basic procedure on a two-conveyance double-drum with no clutch hoist is as follows:



- Raise one conveyance to the highest level and block it.

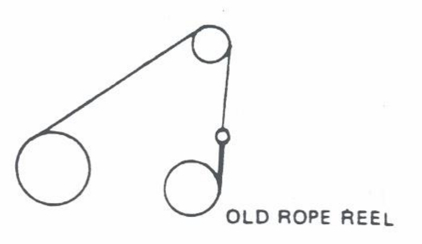


- Remove the old rope from the conveyance.



- Attach the old rope to an empty reel and transfer the old rope from the drum to the empty reel.

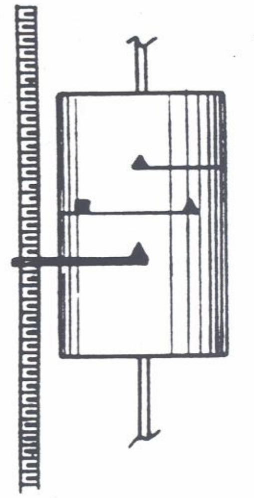
- When the old rope is unwound from the first drum, detach it from the drum and attach a small rope to the old rope.



- Continue winding until all of the old rope is on the reel. The small rope will extend from the drum, through the head sheave to the reel.

Unit 15

DEPTH INDICATOR



The depth indicator shows the vertical position of the conveyance in the shaft.

The depth indicator may be in the form of a dial or a cylinder.

Dial Depth Indicator

Figure 1 shows a dial indicator. The arrow is geared to the drum and moves around the dial. The position of the dump or collar and each working level is indicated on the dial. When the arrow points to a position, the conveyance is at that position.

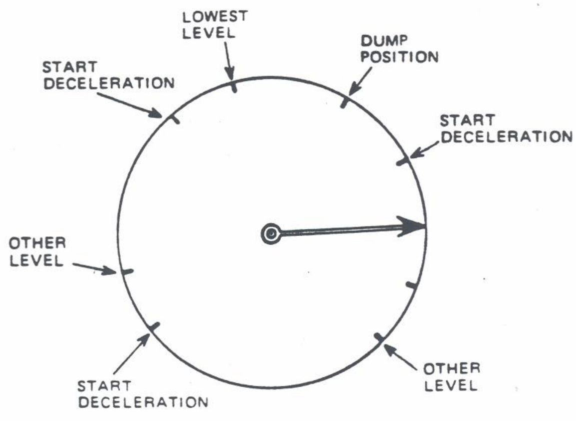


Figure 1

Usually the experienced hoist operator will add other marks at each stopping point to show where he/she must decelerate in order to slow in time to make a smooth stop.

He/she may also make other marks if the stopping point changes because of a heavier load.

Cylinder Depth Indicator

The cylindrical depth indicator is show in Figure 2.

The threaded shaft and the cylinder rotate with the hoist drum.

The indicator moves up and down on the threaded shaft as the conveyance moves up and down the mine shaft.

A point on the cylinder's surface passes under the end of the indicator when the conveyance is at a specific depth.

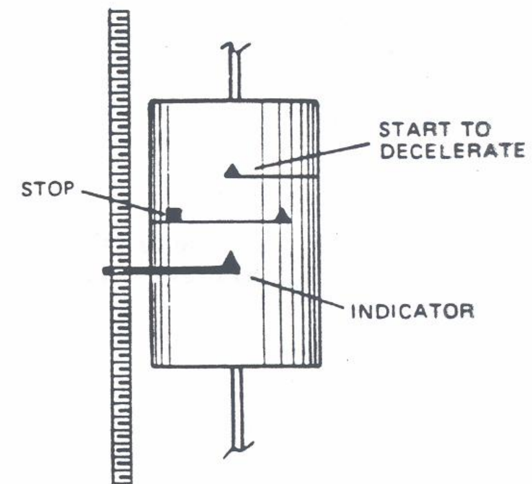
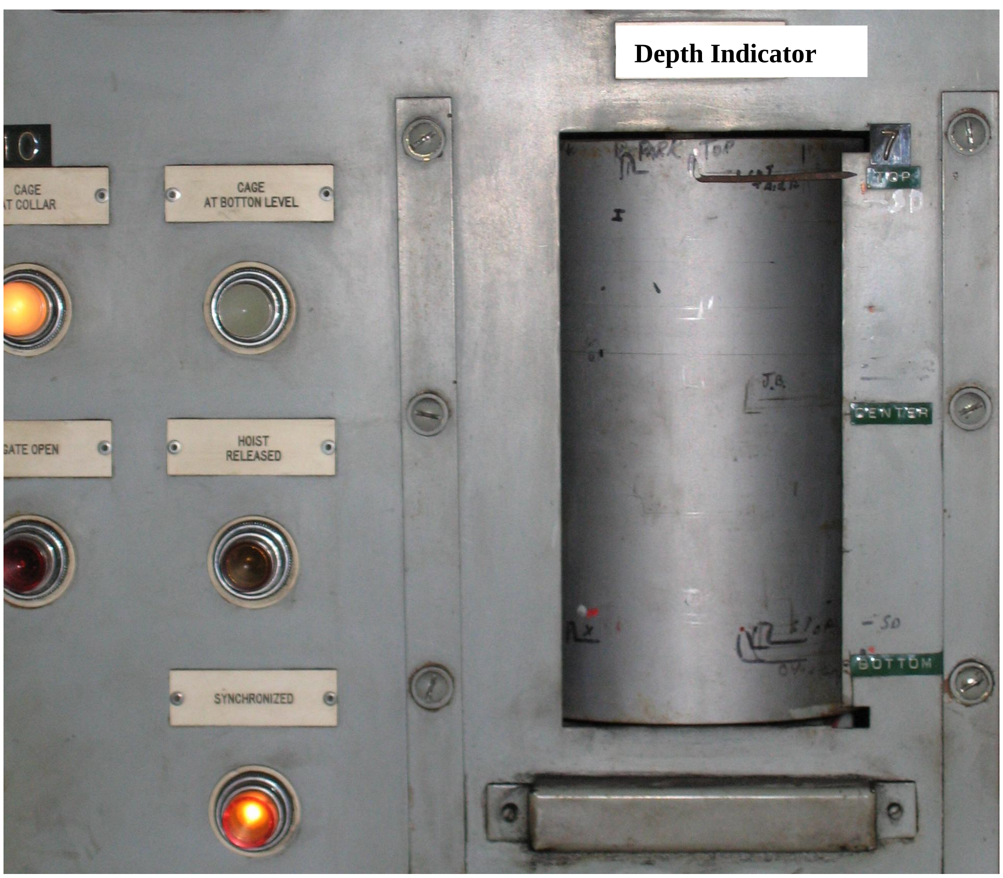


Figure 2



The hoist operator marks the points on the cylinder that correspond to the dump level, working level(s), collar and other significant points in the mine shaft. He/she may also mark points where the conveyance should decelerate, or reach cruise speed, and other points where operator action is required.

Marks on Drum

Experienced operators may also mark the flange of the drum to provide a more accurate and easily read indication of the position of the conveyance.

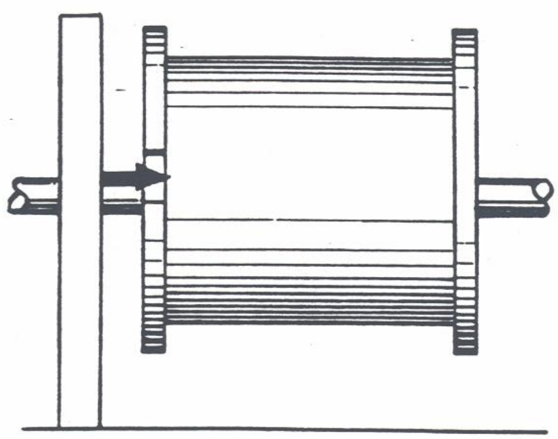


Figure 3

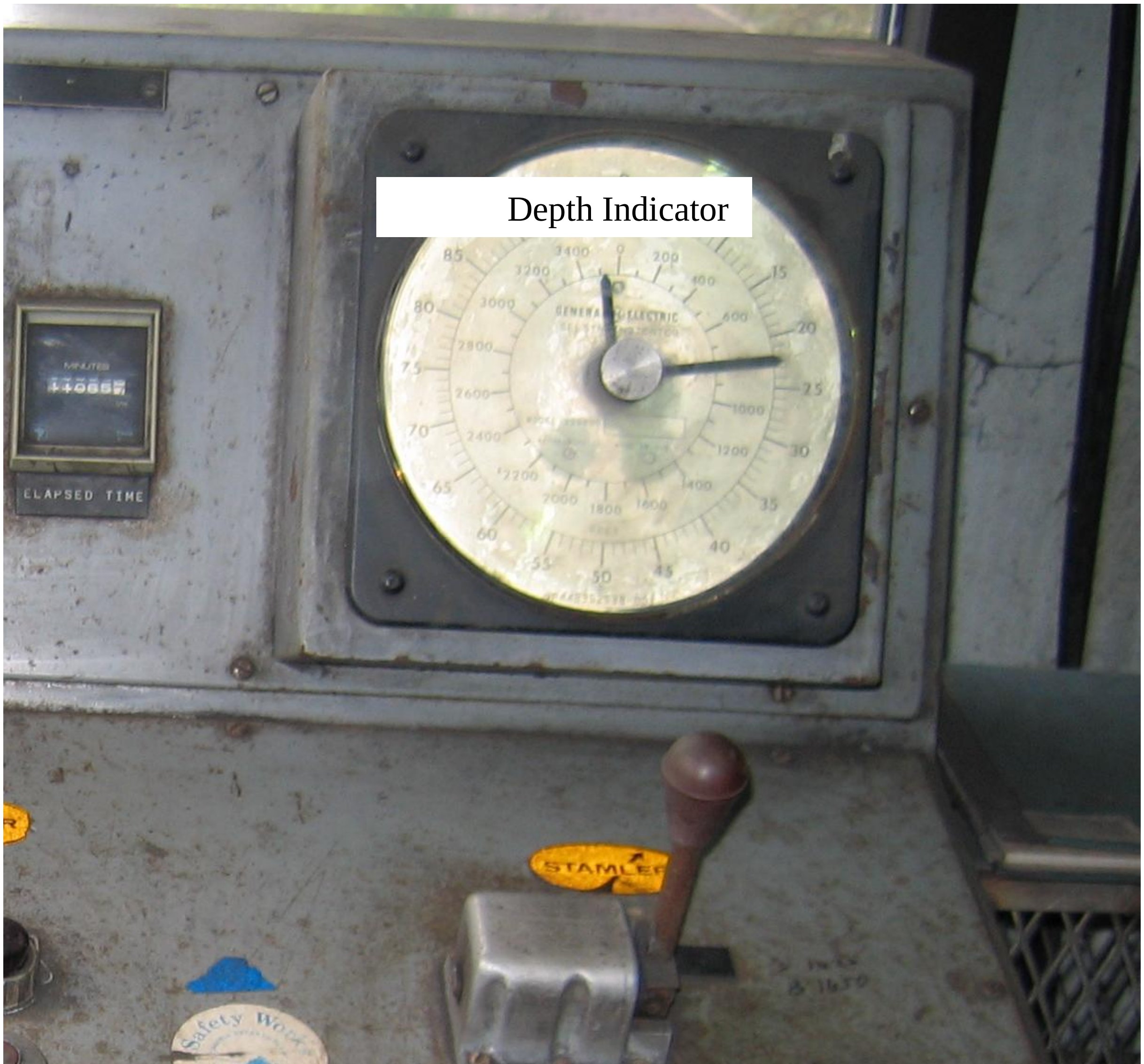
An accurate and reliable indicator of the position of the cage, skip, bucket, or cars in the shaft shall be provided.

COAL MINES

An accurate and reliable indicator of the position of the cage, platform, skip, bucket, or cars shall be provided.

HOISTS: INDICATORS

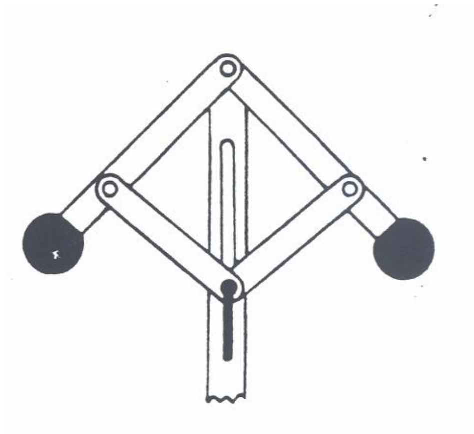
The indicator shall be placed so that it is in clear view of the hoisting engineer and shall be checked daily to determine its accuracy.

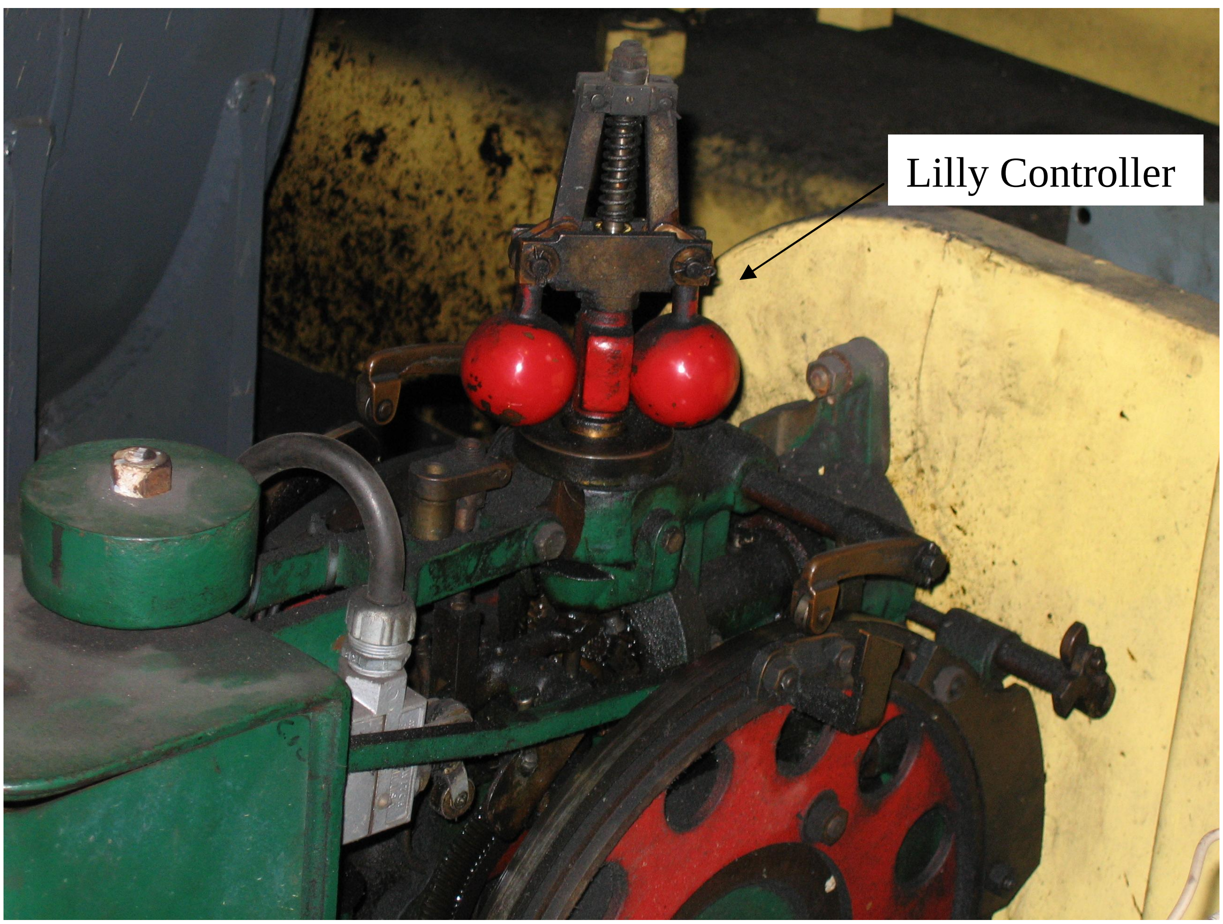


Depth Indicator

Digital Depth Indicator

Unit 16
SAFETY CONTROLLERS





SAFETY CONTROLLER

The Lilly, Simplex or other automatic controller is a multi-purpose safety device synchronized with the movement of the drum shaft. The basic controller prevents overspeed and overtravel, and also applies the brake of an electric hoist in case of power failure.

The controller consists of:

- A <u>governor</u> which prevents overspeed. (See Figure 1)

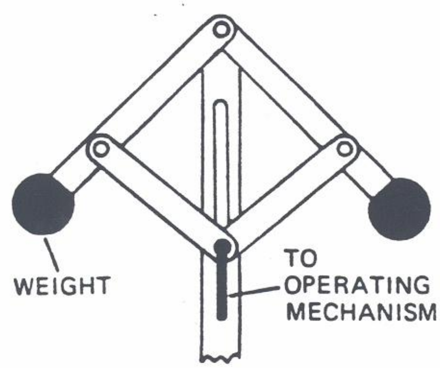


Figure 1

Safe operation of the hoist requires that the conveyance starts moving at slow speed, accelerates to cruising speed, then decelerates to a stop at the destination.

If the drum overspeeds, the weights of the governor will move outward due to centrifugal force and through linkages, cut off power to the hoist motor and set the brake.

- A depth indicator with overtravwel switches. (See Figure 2) This is in addition to the depth indicator discussed in unit I-A-12-2, “Depth Indicator.

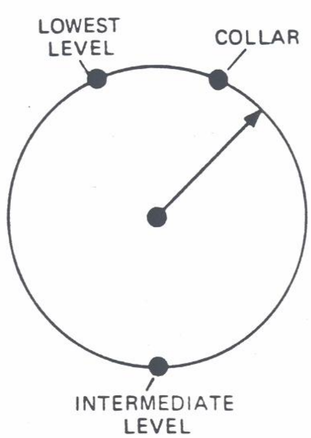


Figure 2

If the conveyance travels too far above the dump position or too far below the lowest working level, power will be cut off from the hoist motor automatically.

The controller is designed to permit only low conveyance speed in the acceleration and deceleration stages, and higher speed only in the cruising stage. Most controllers sound warning bells or buzzers as the conveyance leaves the cruising stage and enters the deceleration stage.

Unit 17
CONTROL PANELS

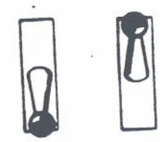
HOIST CONTROL PANEL

The hoist controls and indicators are grouped together on a control panel within easy reach or sight of the hoist operator’s position.

The controls may be set of levers, handles or pushbuttons or switches.

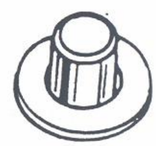
The levers are used for:

- Hoist motor control
- Hydraulic or mechanical brake control
- Clutch control
- Electric brakes



Pushbuttons or switches are used to:

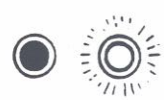
- Control the communication systems
- Override the slack rope, overtravel, deadman and similar safety switches
- Operate the main power switch
- Place the hoist in manual or automatic operation
- Place the hoist in manual or automatic operation
- Start and stop accessories such as the hydraulic System, air compressor or lubrication oil pump.



The indicators may be lights, meters and dials.

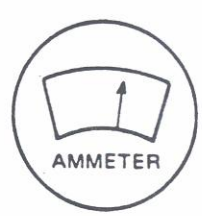
Light indicators show the condition of the hoist components and of other vital mine machinery. These lights may indicate:

- Operating method of the hoist-manual or automatic
- Condition of bypass switch
- Clutches engaged or disengaged
- Safety gates opened or closed
- Precise position of the skip in the loading or dump area
- Warning of low lubrication oil pressure, low hydraulic or air pressure or ventilation or flood control machines not operating
- Various equipments running or stopped.

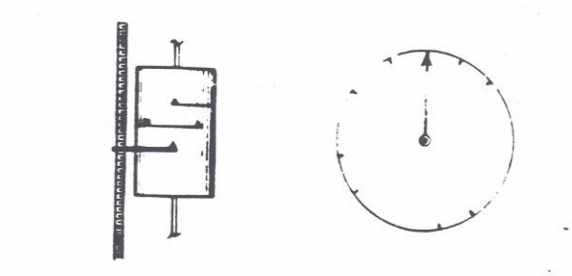


Meters may indicate:

- Lubrication oil, air or hydraulic pressure
- Current flow or voltage
- Rope speed



The depth indicator, which shows the position of the conveyance, may be a dial or cylindrical indicator.



The controls and indicators are grouped around or on the control stand. The levers may be mounted on the stand or on the floor near the stand. Figures 1, 2 and 3 are examples of the arrangement of hoist controls for single drum hoist, double drum hoists with a single clutch and double drum hoists with two clutches. The controls fro the hoist you will operate may have a different arrangement than those shown. The basic controls and indicators, however, will be similar.

Single Drum Hoist

The control panel in Figure 1 is for a single drum hoist.

The bakes are set when the control handle is pulled back and released when it is pushed forward.

The rope on an overwound drum will be lowered when the motor control is pushed forward and raised when the motor control is pulled back.

Electric braking can be done by reversing the motion of the control, that is, pulling the motor control lever back if lowering and pushing it forward if hoisting.

If the hoist has an AC motor with dynamic braking, an additional switch and lever are provided to control the braking.

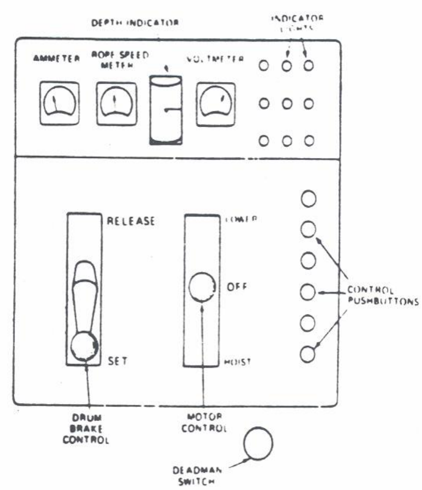


Figure 1

Double Drum, Single Clutch Hoist

The control panel in Figure 2 is for a double drum hoist with a clutch on the left drum only.

The clutch and left drum brake are controlled by the same lever. The clutch is engaged when the lever is pulled to the right and disengaged when it its pulled to the left. The left drum brake must be applied in order to get the clutch operating lever in the disengaged position.

Some control stands have separate operating levers for the clutch and brake. The levers are interlocked, however, to prevent disengaging the clutch when the drum brake is not applied.

Some double drum hoist do not have a clutch and will have only one brake operating lever.

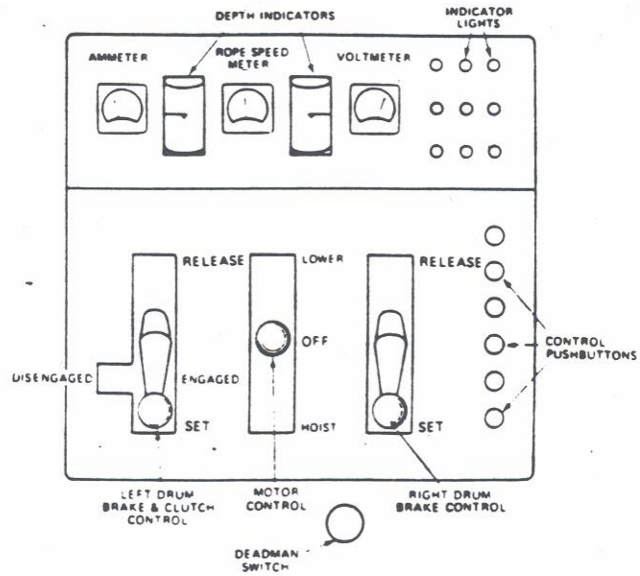


Figure 2

Double Drum, Double Clutch Hoist

The control panel in Figure 3 is for a double drum, double clutch hoist.

The clutches are interlocked with the brakes just the same as in the double drum, single clutch hoist.

Either drum can be operated as a single drum hoist.

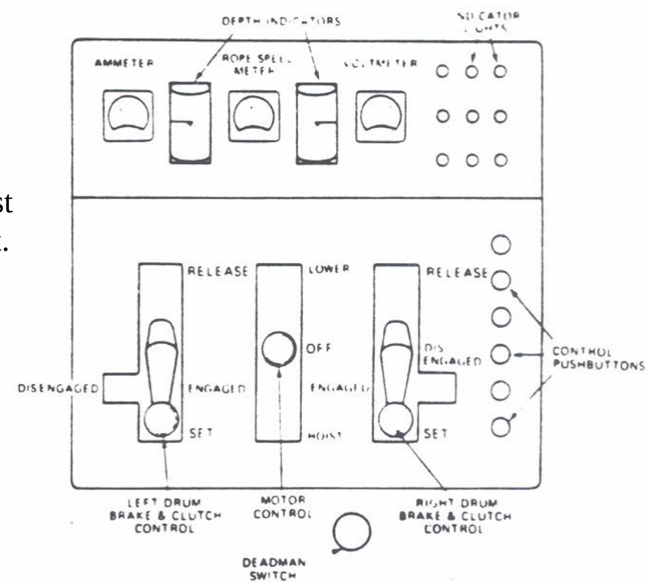
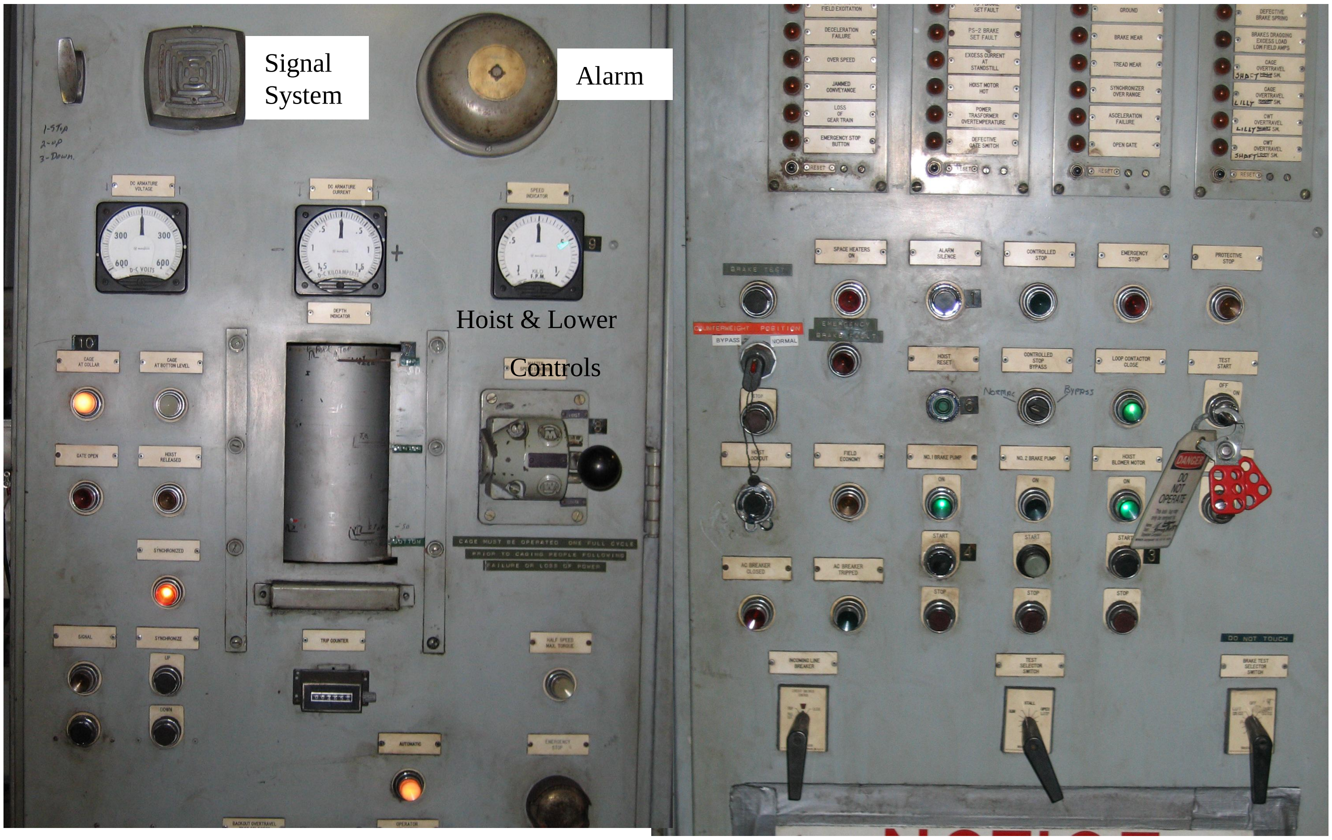


Figure 3

Control Panel For Automatic Operated Hoist



Unit 18

COMMUNICATION SYSTEMS

COMMUNICATION SYSTEMS

Communication systems provide the means of transferring information from one location to another.

Types of information to be transferred:

Direct orders or requests-

The skip tender may request that the skip be lowered to his/her working level.

Explanation of orders or requests-

The skip tender may need the conveyance for a special purpose or precede or follow-up his/her request with an explanation.

Information that indicates the condition of equipment or of the mine environment-

The skip tender may need to inform the supervisor at the surface of the presence of a breakdown of the loader.

Types of communication systems:

- Hoist bell
- Telephone
- High frequency radio
- Public address system
- Indicator lights
- Meters and/or gauges
- Closed-circuit TV

Use of each communication system:

The Hoist Bell is used to request or order the movement of the conveyance. For example, the skip tender, using a series of bells, will signal a request for the conveyance to be brought to his/her level.

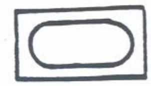
The Telephone or Radio is used for longer messages. For example, the hoist operator may tell the skip tender that the conveyance will not be available for a time. Therefore, the answer to the request will be delayed.

The Public Address system is used to pass information to many people over a wide area. For example, it may be used to give a general announcement or to issue a warning in case of an emergency.

Indicator Lights are normally used to communicate that a malfunction has occurred, that power is on or off, or that a machine is operating. For example, in some mines an indicator light in the hoist room will show that the pumps are running.

Meters and Gauges communicate conditions. For example, the ammeters indicates the load on the motor, the rope meter shows the speed of the rope and the temperature gauges show temperatures in the mine.

Closed Circuit TV provides a view of likely problem areas. The hoist operator is able to observe areas such as the loading pockets and the dumping area.



The specific use of a communication system varies from one mine to another. For example, in some miens the skip tender will telephone the hoist operator before giving a bell signal requesting the use of the hoist.

It is a safe practice for the hoist operator to acknowledge the bell signal prior to answering the request.

In general, basic bell codes are standard, but there are many variations among mines.

The mine hoist operator must be thoroughly familiar with the operating procedures for communication systems of his/her mine.

Example of Hoist Bell Signals

There shall be at least two effective approved methods of signaling between each of the shaft stations and the hoist room, one of which shall be a telephone or speaking tube.

Hoistmen shall accept hoisting instructions only by the regular signaling system unless ii is out of order. During an emergency, the hoistman shall accept instructions only from authorized persons to direct movement of the conveyances.

A method shall be provided to signal the hoist operator from cages or other conveyances at any point in the shaft.

A standard code of hoisting signals shall be adopted and used at each mine. The movement of a shaft conveyance on a “one bell” signal shall be prohibited.

A legible signal code shall be posted prominently in the hoist house within easy view of the hoistmen, and at each place where signals are given or received.

Any person responsible for receiving or giving signals for cages. Skips and mantrips when men or materials are being transported shall be familiar with the posted signaling code.

UNDERGROUND COAL MIENS

There shall be at least two effective methods approved by the Department of signaling between each of the shaft stations and the hoist room, one of which shall be a telephone or speaking tube.

One of the methods used to communicate between shaft stations and the hoist room shall give signals which can be heard by the hoisting engineer at all times while men are underground.

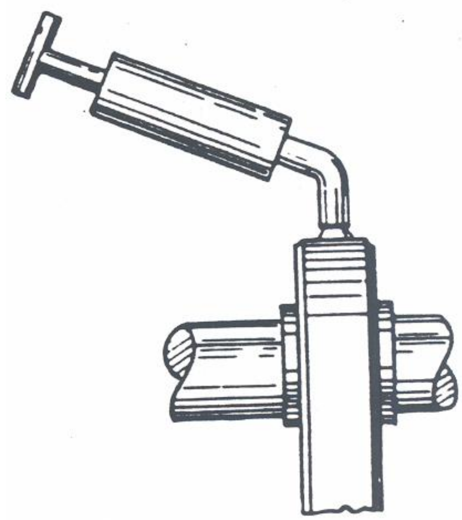
Signaling systems used for communication between shaft stations and the hoist room shall be tested daily.

Unit 19

LUBRICATION

Lubrication prevents wear on surfaces that rub together and is a major part of machinery maintenance.

The typical parts of a mine hoist that require lubricat



- Bearings of all rotating parts
  - hoist motor
  - overspeed and overtravel control
  - hoist drum
  - air compressor
  - head and other sheaves
  - hydraulic pump
- Joints of operating mechanisms
  - brake
  - clutch
  - safety dogs
  - limit switches
  - hoist operating controls
- Other surfaces that rub together
  - shaft guides and conveyance guide shoes
  - hoist rope

The types of lubricant are:

- oil
- grease

The methods of application are:

- Oil
  - Oil Reservoir

    The bearing or part to be lubricated is submerged in oil. A dipstick or sight glass is provided to indicate if the oil is at the proper level. (See Figure 1)

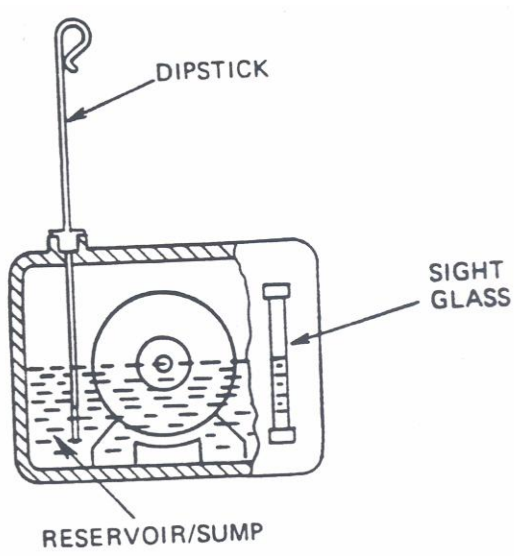


Figure 1

- Oil Flow System

Oil is fed to the bearing from an elevated tank by gravity or by a pump. After flowing through the bearing, the oil drains into a sump. A pump takes the oil out of the sump and pumps it to an elevated tank or directly to the bearing. A sight glass is usually provided to show whether or not oil is flowing in the required amount. A sight glass or dip stick can be used to show if there is sufficient oil in the tank or sump. The gauge measures oil pressure. (See Figure 2)

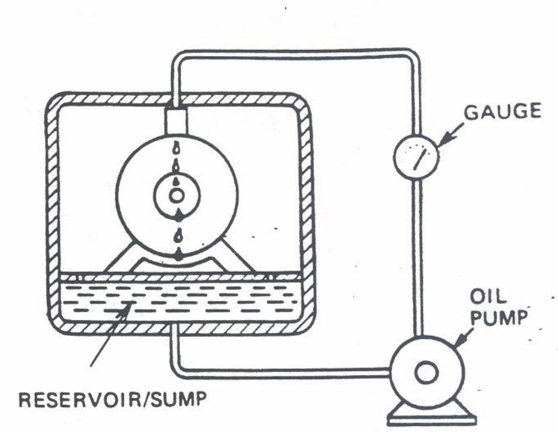


Figure 2

- Grease

Grease is forced between the parts to be lubricated (shaft and bearing, for example) by a grease gun. (See Figure 3)

The gun may be attached or portable. If it is attached it my be operated automatically or manually.

An adequate supply of grease should always be in the gun.

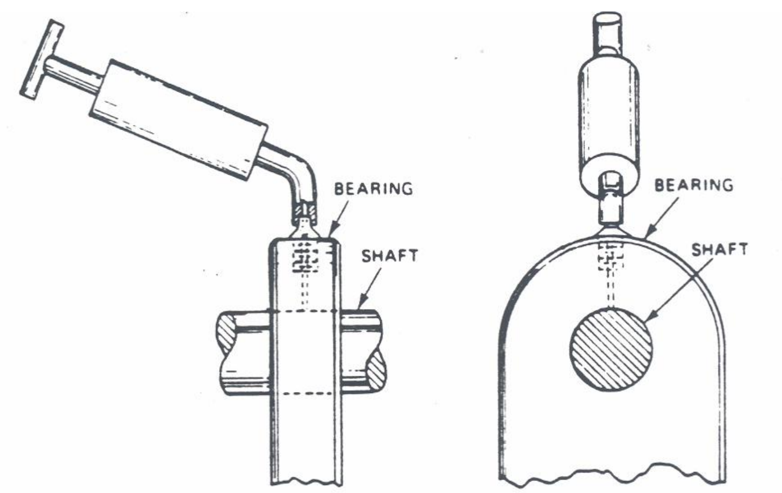


Figure 3

The person responsible for lubricating the hoist machinery must know:

- the parts to be lubricated
- the method of lubricating each part
- the type of lubricant (grade and weight or oil-type of grease) used for each part
- the location of the lubricant storage

The application of the lubricant to the shaft guides is usually done with a mop or brush.

The application of the lubricant to the hoist rope will be covered in that unit.

The manufacturers of practically all equipment include recommendations for lubrication in the instruction manual. These recommendations may be modified in your organization by the people responsible for maintenance. These instructions or modified instructions should be followed closely.

Complete records must be kept of installation, lubrication, inspections, tests and maintenance of shafts and hoisting equipment.

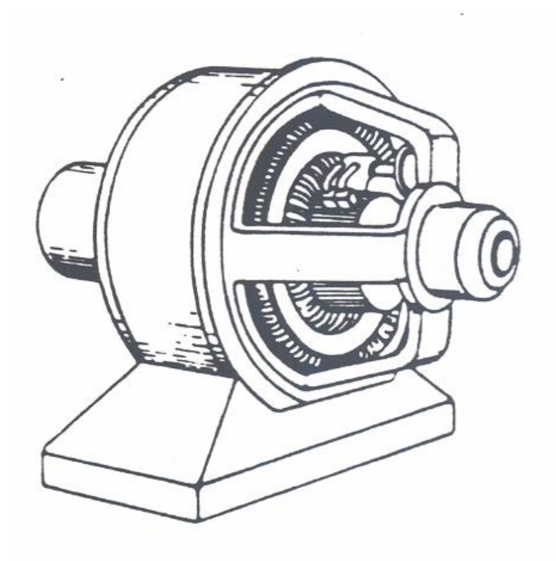
Ropes shall be kept well lubricated from end to end as recommended by the manufacturer.

Sheaves shall be inspected daily and kept properly lubricated.

Rollers used in inclined shafts shall be lubricated, properly aligned and kept in good repair.

Unit 20

ELECTRICAL SYSTEM



The trainee will be able to answer in writing questions concerning the basic principles of :

1. electricity
2. magnetism
3. direct current motors
4. alternating current motors
5. direct current generators
6. alternating current generators
7. transformers
8. fuses and circuit breakers
9. work and power relationships
10. safety precautions for electricity

The trainee will be able to solve simple problems using Ohm's Law.

Electricity provides energy for operating the mine hoist and other equipment and for lighting and heating. (see Figure 1)

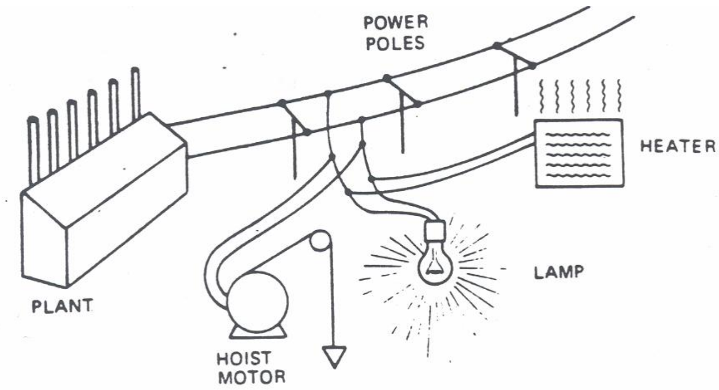


Figure 1

Like other forms of energy, electricity, if not carefully controlled, can cause injuries to people and damage to equipment.

A knowledge of the material in this unit will enable the hoist operator to operate the mine hoist and its supporting equipment with a high degree of safety from electrical hazards.

ELECTRICITY

Electrical energy is created by a flow of negatively charged atomic particles called electrons. If there are more electrons at point A (Figure 2) than there are at point B, and there is a path (conductor) through which the electrons can flow, electrons will move from point A to B

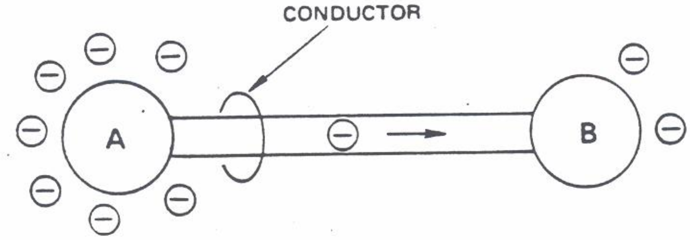


Figure 2

Until an equal number are at each point (Figure 3).

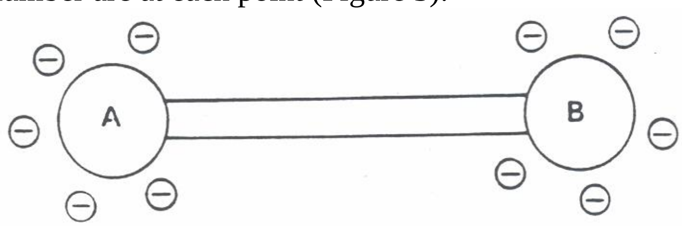


Figure 3

The excess number of electrons at A in Figure 2 created a pressure, causing the electrons to flow to point B. You can compare the action to the two tanks of water in Figure4.

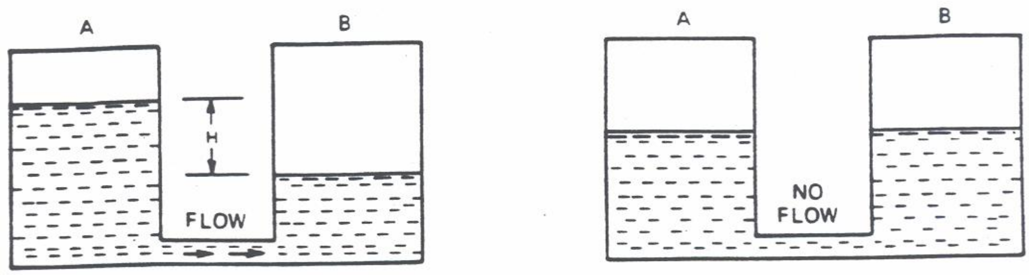


Figure 4

The greater water pressure caused by the greater height of the water in A (H) will cause water to flow into B until the water in each tank is at the same height.

PRESSURE AND CURRENT

Volts and Amperes

In electricity the "pressure" causing the flow is called <u>voltage</u>. The rate of flow of electrons is called <u>current</u>.

A unit of voltage is one <u>Volt</u>.
Its symbol is <u>E</u>.
A unit of current is one <u>Ampere</u>.
Its symbol is <u>I</u>.

It is important to remember that if there is a difference in voltage and a path along which electricity will flow (conductor) between two points, current will flow from the high voltage to the low voltage point.

RESISTANCE – OHMS

In the water system resistance is a restriction that opposes the flow of water. For example, if we use a smaller pipe between the two tanks, the rate of flow of the water will be less than if we use a larger pipe. With the smaller pipe we have put a resistance to the flow of water in the path (See Figure 50.

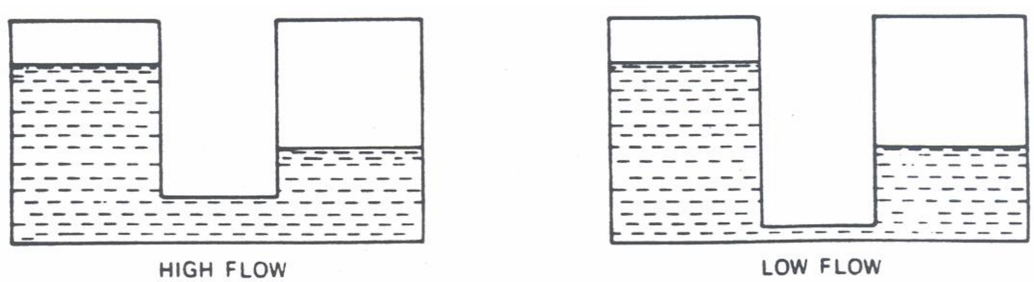


Figure 5

If we put a resistance in the path of the electrons (a smaller conductor or a conductor of a material that does not allow electrons to flow as well), Figure 6, the rate of flow of electrons will be reduced.

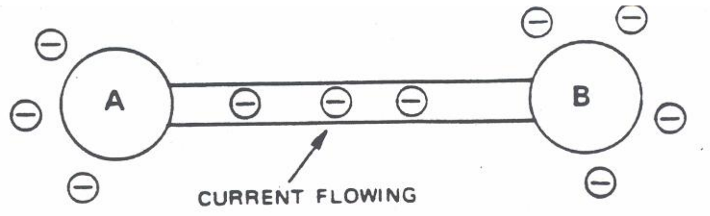


Figure 6

In an electrical circuit a unit of resistance to flow is an <u>Ohm</u>.

Its symbol is <u>R</u>.

Now go to the Questions and answer 1 through 10

… …

There is a relationship between the number of volts, amperes and ohms in an electrical circuit. It is called <u>Ohm's Law</u>.

Here are the relationships:

Volts = Amperes x Ohms	<u>Symbols</u> $E = IR$
Amperes = $\frac{\text{Volts}}{\text{Ohms}}$	$I = \frac{E}{R}$
Ohms = $\frac{\text{Volts}}{\text{Amperes}}$	$R = \frac{E}{I}$

These relationships enable us to find one unknown value if two others are known. For example, if we have 5 amperes flowing through a circuit with 10 ohms resistance, what is the voltage?

E (Volts) = 1 (Amperes) x R (Ohms)
or, E = 5 x 10 = 50 Volts.
The circuit would look like Figure 7.

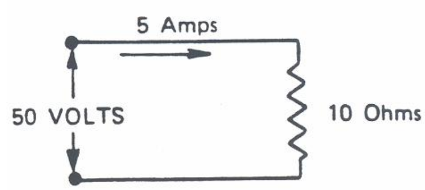


Figure 7

Or, if we have 100 volts across a 5 ohm resistance (Figure 8), how many amperes are there?

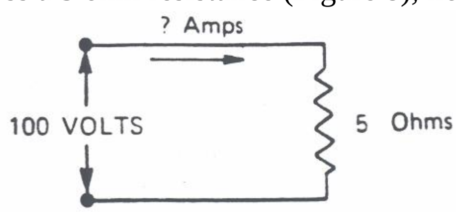


Figure 8

The current flow will be

$$I = \frac{E}{R} = \frac{100}{5} = 20 \text{ Amperes}$$

And, if we have 75 volts causing 25 amperes to flow in a circuit (Figure 9), what is the resistance in the circuit?

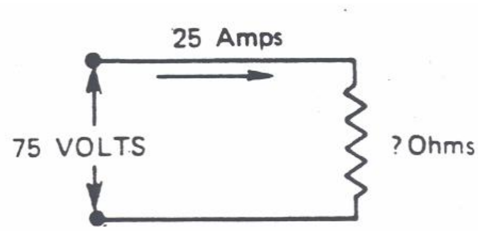


Figure 9

$$R = \frac{E}{I} = \frac{75}{25} = 3 \text{ Ohms.}$$

Now go to the Questions and answer 11 through 17

. . . .

SERIES AND PARALLEL CIRCUITS

There are two types of circuits: series and parallel (See Figure 10).

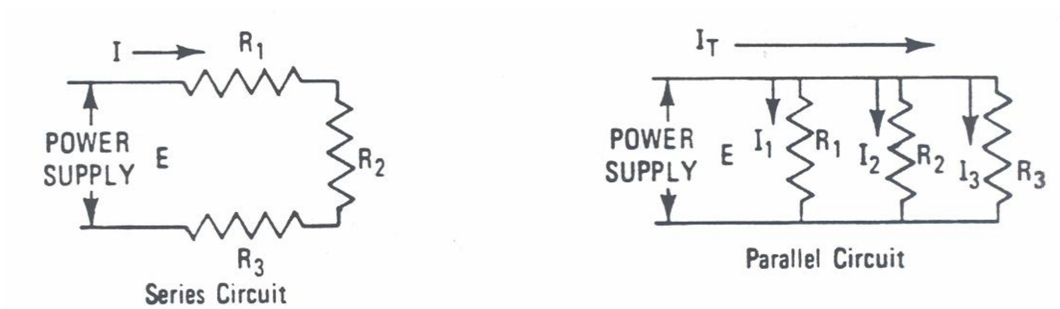


Figure 10

In a series circuit the same amount of current flows through each resistance (or load) in the circuit. The total resistance in the circuit is equal to the sum of the resistances, that is $R_T = R_1 + R_2 + R_3$. The current flowing through each resistance is equal to the voltage (E) divided by that sum:

$$I = \frac{E}{R_1 + R_2 + R_3}$$

In a parallel circuit the amount of current flowing through each resistance (or load) is equal to the voltage (E) divided by that resistance:

$$I_1 = \frac{E}{R_1};\ I_2 = \frac{E}{R_2};\ I_3 = \frac{E}{R_3}$$

The total current $I_T = I_1 + I_2 + I_3$.

For example, in a 100 volt series circuit there are 3 resistances, one of 5 ohms, one of 8 ohms and one of 12 ohms. What is the current flow?

$$I = \frac{E}{R = R = R} = \frac{100}{5 + 8 + 12} = \frac{100}{25} = 4 \text{ Amperes.}$$

In a 100 volt parallel circuit we have three resistances (or loads), one of 5 ohms, one of 10 ohms and one of 20 ohms. How much current flows through each one? What is the total current?

$$I_1 = \frac{E}{R_1} = \frac{100}{5} = 20 \text{ amps}$$

$$I_2 = \frac{E}{R_2} = \frac{100}{10} = 10 \text{ amps}$$

$$I_3 = \frac{E}{R_3} = \frac{100}{20} \; 5 \text{ amps}$$

$$I_T = I_1 + I_2 + I_3 = 20 + 10 \; 5 = 35 \text{ amps}$$

Now go to the Questions and answer 18 and 19

. . . .

CONDUCTORS AND INSULATORS

Practically every substance will conduct electricity to some extent. Those that have low resistance are called Conductors; those that have high resistance are called Non-conductors. Non-conductors are used as Insulators.

Commonly used conductors are listed below from lowest to highest resistance:

Silver
Copper
Gold
Aluminum
Carbon

Silver, of course, is used only in rare cases, and in very limited amounts because of its cost.

The best and most commonly used non-conductors are:

Rubber
Porcelain
Glass
Some Plastics

There is no perfect conductor or non-conductor.

Most conductors are in the form of wire, made of copper or aluminum.

The diameter of the wire is given in thousandths of an inch or Mils. A wire with a diameter of 5 thousandths of an inch is 5 Mil wire. The cross-section of the wire in Figure 11 is 5 Circular Mils.

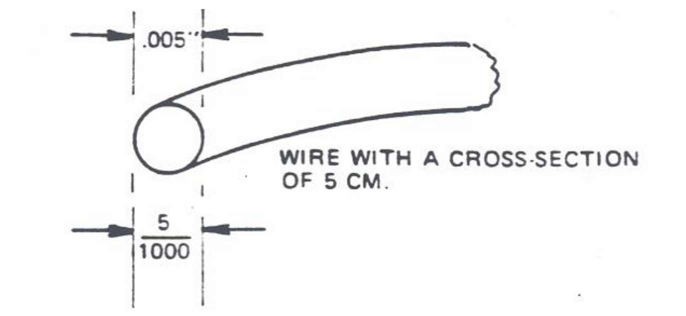


Figure 11

ELECTRICAL POWER SYSTEMS

We can't actually see electricity flow through a wire and do work for us. We can, however, readily understand its basic operating principles by comparing it to a simple power system hat is easily understood.

An electrical poser system is similar to a water power system Figure 12 is a sketch of a water powered system Water is stored behind the dam and creates a pressure to force water through the pipe. When the valve is opened water flows through the pipe and turns the water wheel. The greater the pressure the greater the rate of flow of water. The greater the flow or water the greater the amount of power generated by the turning wheel.

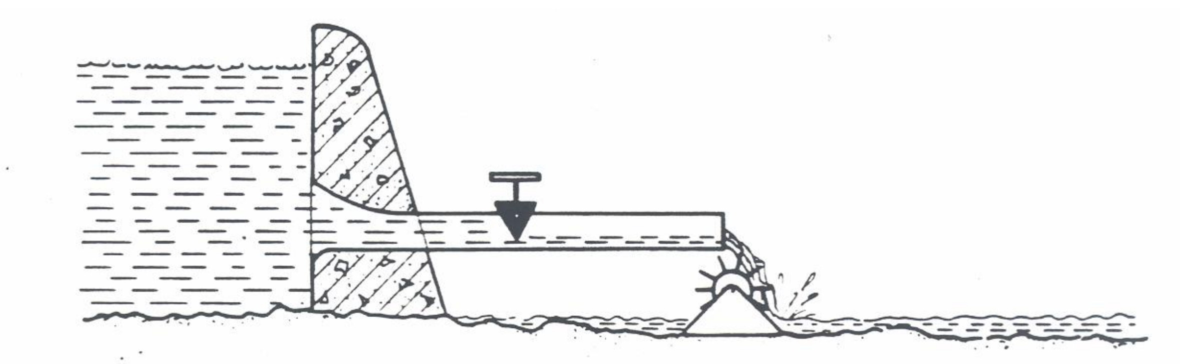


Figure 12

In an electrical power system, Figure 13, we have a similar situation. Electricity is like the water. It comes from a battery or generator and flows through wires or conductors. Remember that the pressure that forces it through the conductors is the voltage and the rate of flow of electricity is the current. Voltage is measured with a voltmeter; current is measured with an ammeter. (See Figure 14) The greater the number of volts, the greater the number of amperes and the greater the amount of power, light or heat that is generated.

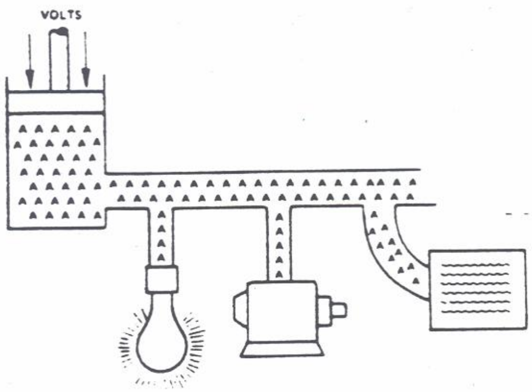


Figure 13

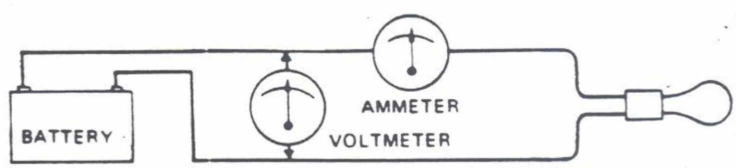


Figure 14

Too much pressure in a water system will increase the flow of water to the point that the pipes or equipment will be damaged (See Figure 15).

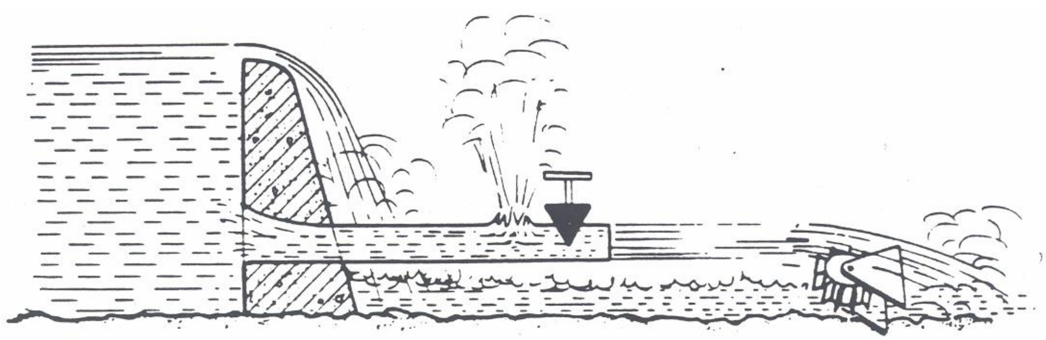


Figure 15

Too much voltage in an electrical system will increase the current to the point that the conductors or equipment will be damaged (See Figure 16).

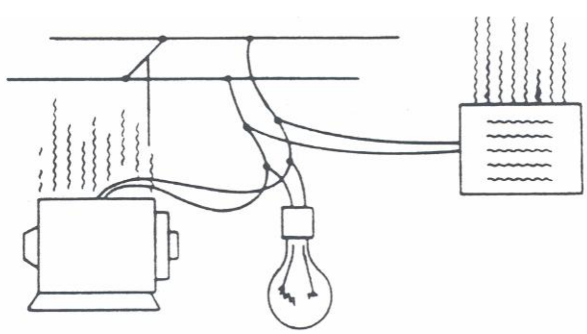


Figure 16

POWER – WATTS

For our purpose, Power is the rate at which a motor or engine does work. Power is equal to the pounds lifted times the number of feet the pounds were lifted, divided by the number of seconds that it took to do the lifting.

$$\text{Power} = \frac{\text{Pounds x Feet}}{\text{Seconds}}$$

A basic unit of power is foot pound per second. If a hoist lifts one pound one foot in one second it exerted one foot pound per second of power (Figure 17).

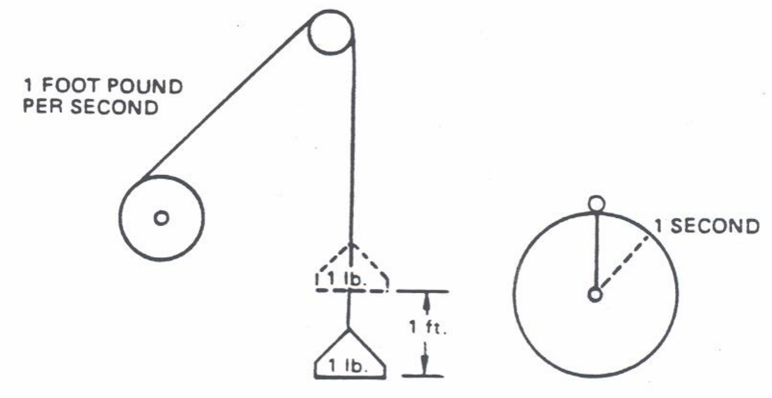


Figure 17

If the hoist lifts 5 pounds 10 feet in 2 seconds, it used 25 foot pounds per second of power (Figure 18).

$$(\text{Power} = \frac{\text{5 pounds x 10 feet}}{\text{2 seconds}} = \text{25 foot pounds per second})$$

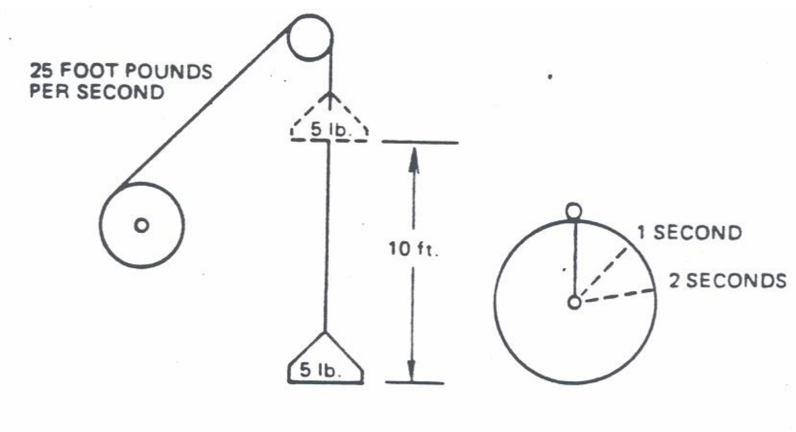


Figure 18

WORK

The work done by the motor or engine is equal to the pounds that were lifted or force that was exerted, times the distance the pounds were lifted, or distance through which the fore was exerted.

(Work = Pounds x Feet)

If we lift 1 pound 1 foot we do 1 foot pound of work. If we lift 1 pound 3 feet we do 3 foot pounds of work. If we lift 2 pounds 3 feet we do 6 foot pounds of work (Figure 19).

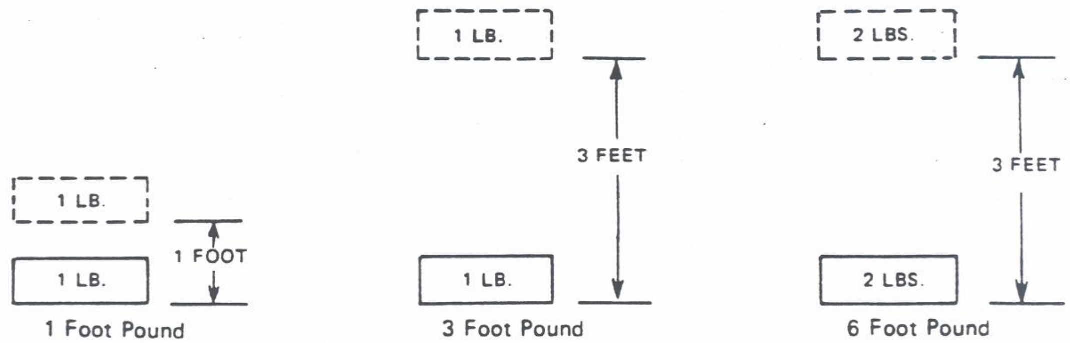


Figure 19

WORK AND POWER

We can also determine the amount of work done by multiplying the power exerted by a motor or engine by the time that it operated (Work = Power x Seconds). For example, the hoist in Figure 18 raised 5 pounds 10 feet in 2 seconds. It did 50 foot pounds of work in 2 seconds, or 25 foot pounds each second.

25 foot pounds per second of power x 2 seconds = 50 foot pounds of work

HORSEPOWER

Horsepower is a common term used to express power. One horsepower is the power needed to do 550 foot pounds of work in one second or 33, 000 foot pounds of work in one minute. If a hoist has a 100 horsepower motor, it could do (550 x 100) foot pounds of work in one second, that is, 55,000 foot pounds. It might lift a 550 pound weight 100 feet in one second or a 55, 000 pound weight one foot in one second (Figure 20).

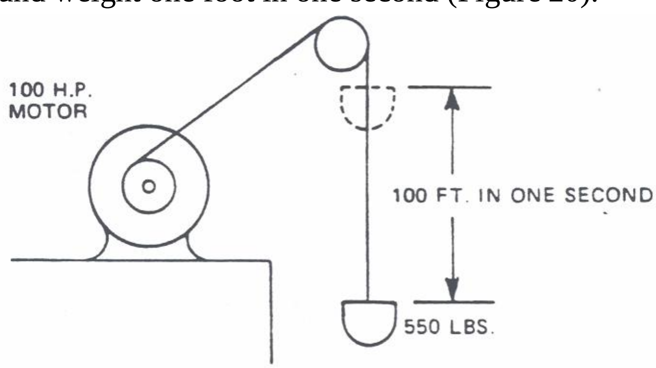


Figure 20

In one minute the 100 HP motor could hoist a 33,000 pound weight 100 feet.

Suppose your production hoist has two skips and tail ropes. The hoist will lift 15, 000 pounds of ore at a speed of 2,200 feet per minute. If you ignore friction losses, how many horsepower are needed to run the hoist?

The work to be done in one minute is : 15,000 pounds x 2,200 feet = 33,000,000 foot pounds.

To convert the 33,000,000 foot pounds per minute to horsepower, divide the 33,000,000 foot pounds per minute by 33,000 foot pounds per minute for each horsepower.

$$\text{Power required is} = \frac{33{,}000{,}000}{33{,}000} = 1{,}000 \text{ horsepower}$$

We can find out how much work the motor has done by multiplying the power by the time that the power is used. For example, if the above hoist operates for 10 minutes, it will do 1,000 x 33,000 x 10 or 330,000,000 foot pounds of work.

. . . .

WATTS, KILOWATTS AND KILOWATT HOURS

Power for electrical machinery is expressed in Watts. One horsepower is equal to 746 watts.

When one volt causes a one ampere current to flow in an electrical circuit, one watt of power is used. The symbol for Power is P. The power may hoist ore, turn a fan, pump water, light a lamp or provide heat. Since the watt machine operates for one hour it will do one Kilowatt, that is , 1,000 watts. If a one watt machine operates for one hour it will do one watt hour of work, or you can say that it used or expended one watt hour of energy. If a 10 Kilowatt machine operates for one hour, it does 10 Kilowatt hours of work.

Electric power used can be calculated by multiplying the voltage times the current flow, that is P = E x I. If 100 volts causes 5 amperes to flow in a circuit, the power used is P = E x I = 100 x 5 = 500 watts. If the voltage and current flow continues for 2 hours, 1,000 watt hours of work 9or one Kilowatt hour) are done. The power company bills the consumer on the number of Kilowatt hours of energy used.

WATT HOUR METER

A Watt Hour Meter is used to measure the power or energy used. The watt hour meter actually measures the voltage and the amperage and combines the two measurements along with a time factor through a mechanical linkage in the meter.

Thus work or energy used = Volts x Amperage x Hours

RESISTANCE AND POWER

We can use the Ohm’s Law relationships on page I-A-20-4 to develop a similar formula for determining power. For example, we had:

$$P = E \times I$$

If we replace E with its formula ($E = IR$) from page I-A-20-4 we have $P = I \times R \times 1$ or $1^2 \times R$. Thus if we have 5 amperes flowing through a circuit with 40 ohms resistance, the power used in the circuit is:

$$P = 1^2 \times R = 5 \times 5 \times 40 = 1000 \text{ Watts}$$

. . . .

The power that is used when current flows through the resistance in conductors turns into heat and is usually wasted. This fact creates two problems: one problem is the loss of power in transmission from the power company to the customer;: the other problem is the creation of a fire hazard.

TRANSMISSION OR LINE LOSSES

Suppose the mine receives power from the power company. The power company sends 100,000 watts at 1,000 volts and 100 amperes. Assume that the power lines have a resistance of 2 ohms.

In this case there will be a power transmission loss (line loss) of $I^2 \times /r = 100 \times 100 \times 2$, or 20,000 watts. Thus while the power company sent 100,000 watts, we only receive 80,000.

If the power company sent the power at 2,000 volts and 50 amperes, the transmission or line loss would only be : $I^2 \times R = 50 \times 50 \times 2$, or 5,000 watts, and 95,000 watts would be received instead of 80,000.

Since line losses increase very rapidly as we increase the current, electricity is usually transmitted at very high voltage and low amperage.

The problem of a fire hazard is created when there is a poor connection, too small a conductor, or a damaged conductor between the power supply and the load that creates additional resistance. Fro example, a motor draws 10 amperes at normal load. If there is a bad connection in the conductor to the motor controls or switch boxes, the resistance at that point increases. For each ohm that it increases, 100 watts of power are lost and turn into heat.

$$P = I^2 \times R = 10 \times 10 \ 1 = 100$$

The heat may burn the insulation off the conductor, ignite flammable materials in the vicinity and start a fire.

. . . .

ELECTRICITY AND MAGNETISM

The hoist motor and motor generator operate as they do because of certain relationships between electricity and magnetism. This section will explain those relationships.

If direct current electricity flows through a coil of wire that is wrapped around a piece of iron ("core") in the direction shown by the Arrow ➡, the iron will become a magnet. The magnetic lines of force are indicated. The magnet's North and South Poles will be as indicated by S and N. (See Figure 21). This kind of magnet is called an electromagnet since it is created by electricity.

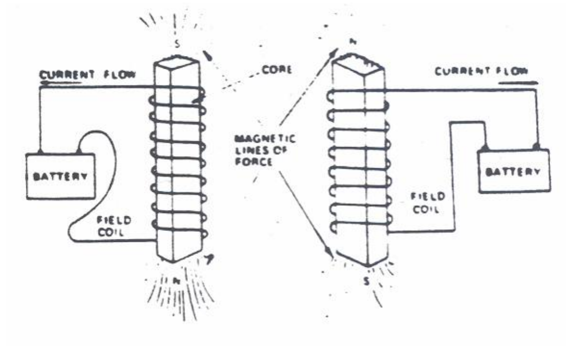


Figure 21

If the number of wire turns or the current flow throu of the magnetic field will be increased (See Figure 22).

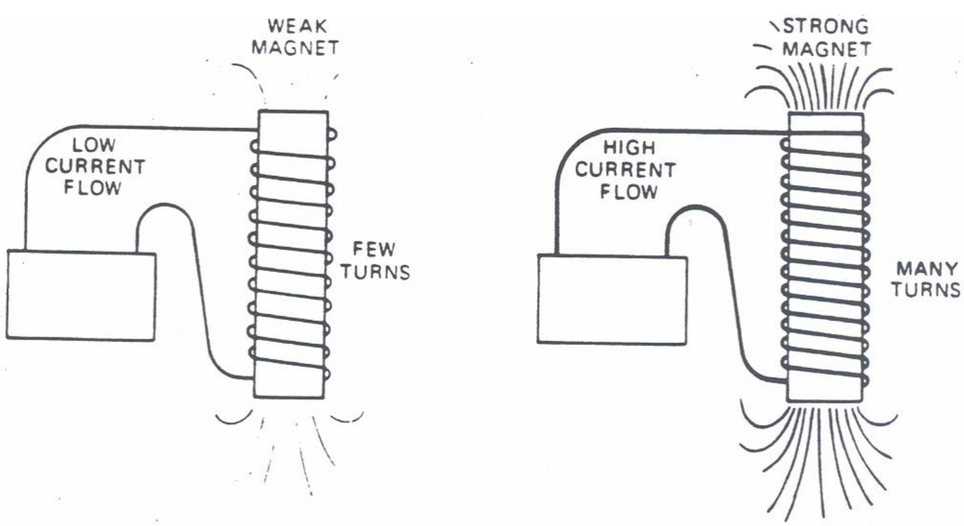


Figure 22

Opposite poles, an N and S, attract each other. (See Figure 23). Like poles, N and N or S and S repel each other (See Figure 24).

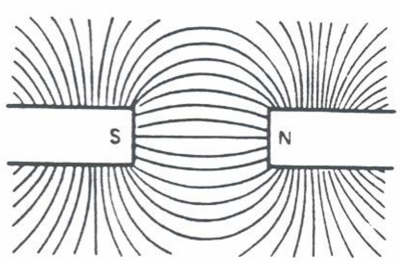


Figure 23

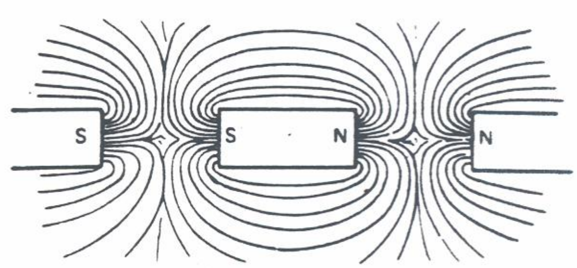


Figure 24

There are electromagnets inside the mine hoist motors. The attracting and repelling forces between the magnets cause the shaft of the hoist motor to turn.

In Figure 25A a wire is passed from left tot right through the magnetic field. A voltage is generated in the wire. If the two ends of the wire are connected, current will flow.

In Figure 25B the direction of motion of the wire through the magnetic field is from right to left. The current flow is in the opposite direction from Figure 25A.

In Figure 25C the position of the poles of the magnetic field are opposite to those in Figure 25A. Changing the position of the poles changes the direction of current flow.

if the strength of the field is increased and/or the speed of the wire passing through the field is increased the voltage generated is increased.

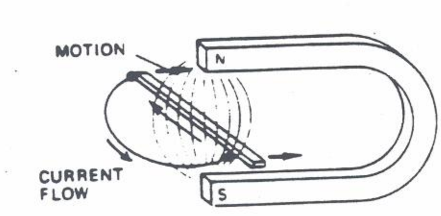


Figure 25A

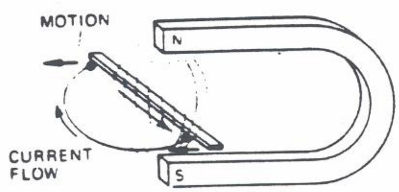


Figure 25B

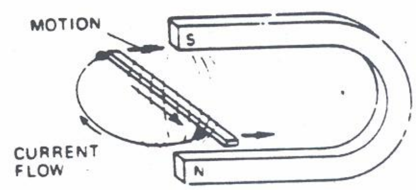


Figure 25C

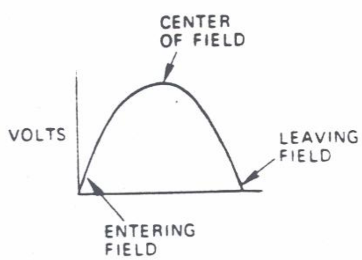


Figure 26

The voltage in the wire changes as the wire passes through a magnetic field. It is:

- Low on entering the field
- At a peak in the center of the field
- Low on leaving the field

(See Figure 26).

The generator that supplies power to the hoist motor operates on these principles. Control of the hoist motor is also affected by these principles.

There are two kinds of electricity: Direct Current and Alternating Current. With direct current the voltage causes the current to flow in one direction only. The voltage may vary in the amount but not in the direction. (See Figure 27)

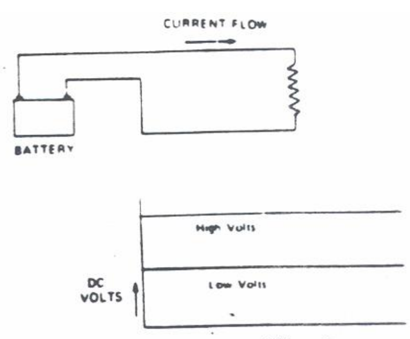


Figure 27

For alternating current the voltage causes current to flow first in one direction, then in the opposite direction. The voltage starts at zero, rises to a peak in one direction, drops to zero then to a peak in the opposite direction, then rises back to zero. (See Figure 28).

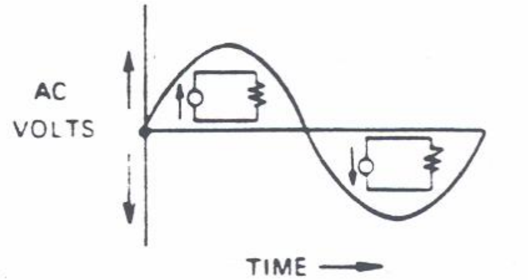


Figure 28

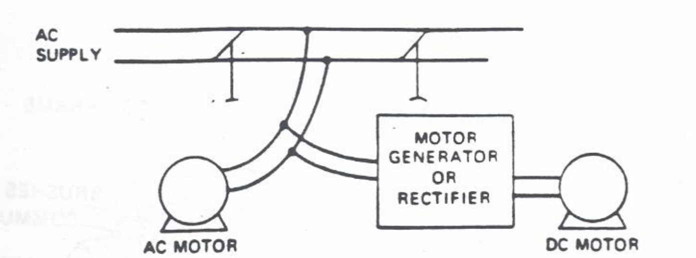


Figure 29

Most commercial electricity is generated and transmitted to the customer as alternating current. Some mine hoists and other mine equipment operate on alternating current while others operate on direct current. Where direct current is used the alternating current must be changed to direct current. A motor generator set (alternating current motor driving a direct current generator) or a rectifier is used for this purpose. (See Figure 29)

DIRECT CURRENT VS. ALTERNATING CURRENT

There are advantages and disadvantages in using both AC and DC current:

• Alternating current is more dangerous: 1/10 ampere of alternating current gives a fatal shock: however, it takes five times as much direct current (1/2 ampere) to give the same shock.

• The voltage of alternating current can be raised or lowered with very little loss in a simple transformer; changing direct current direct current voltage requires complex electronic circuits.

• Direct current voltage can b e lowered by passing it through a Rheostat, a resistance whose value can be changed; however, this procedure wastes power.

• The speed and power output of direct current motors can be adjusted and varied much more simply and efficiently than the speed and power output of alternating current motors.

. . . .

The hoist motor changes electrical energy into rotary motion. The generator that supplies power to the hoist changes rotary motion into electricity. A generator may also be called a dynamo. Since there are differences between alternating current and direct current motors and generators, we will describe them separately.

Direct Current Motor: It has four principal parts: (See Figure 30)

- The field magnets which are mounted in the motor frame. The field magnets are electromagnets (that is, cores wrapped in coils of wire.)
- The armature which is the rotating part of the motor and mounted inside the motor frame. The armature consists of several electromagnets (cores with their coils) mounted on a shaft.
- The commutator which is a series of segments of a circle arranged around and attached to the armature shaft. Each segment is connected to one of the armature's electromagnet coils.
- The brushes are attached to the motor frame and touch the commutator. They provide a path for electricity from the power supply through the commutator to the electromagnet coils in the armature. (See Figure 31)

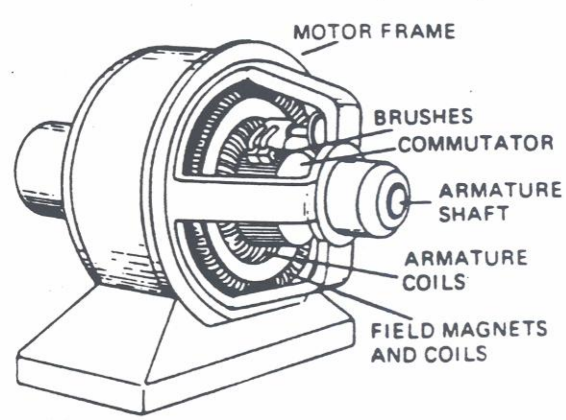


Figure 30

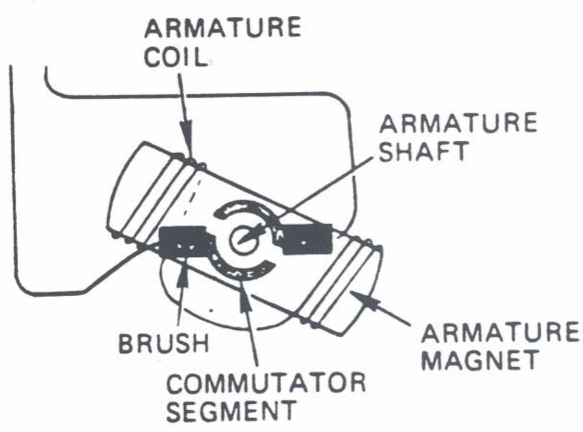


Figure 31

A Direct Current Motor operates on these principles:

- If we reverse the flow of current through the coil of an electromagnet, the poles of the magnet are reversed.
- Opposite poles attract each other.
- Like poles repel each other.

Industrial motors, like this one in Figure 30, have several armature magnets with two commutator segments for each one. They may also have more than one field magnet. In order to explain the operation of a direct current motor we will use a simple motor which has only these parts:

- One field magnet
- One armature magnet
- Two commutator segments

Note in Figures 32 through 34 that the poles of the field magnet do not change.

In Figure 32 the armature poles are the same. The nearest field poles, therefore, are being repelled, causing a clockwise rotation of the armature.

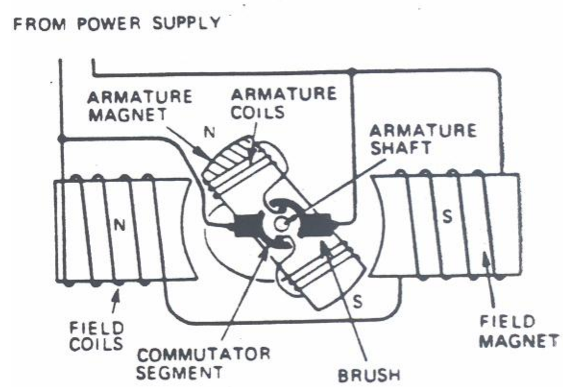


Figure 32

In Figure 33 the armature has continued its clockwise movement and the armature poles are being attracted by the opposite field poles.

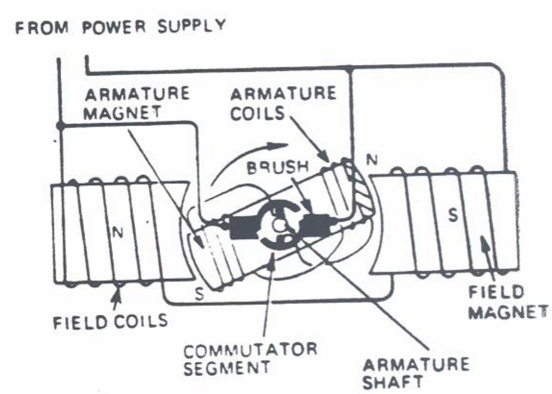


Figure 33

In Figure 34 the armature has passed through the horizontal position and the brushes have switched to opposite segments of the commutator. Current flow in the armature coils is reversed:; the armature poles are reversed and are now being repelled by the field poles to continue the clockwise motion. The rotary motion of the armature can be used to turn the hoist drum, hydraulic pump and other machinery.

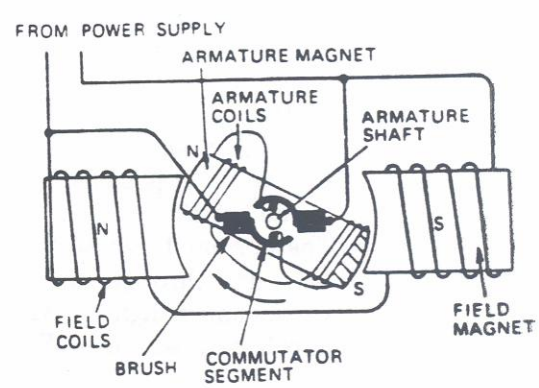


Figure 34

Increasing or decreasing the armature current will increase or decrease the magnetic forces which turn the armature and therefore, increase or decrease the power output of the motor. (See Figure 35) A direct current motor is reversed by changing the direction of current flow in either the armature or the field coils.

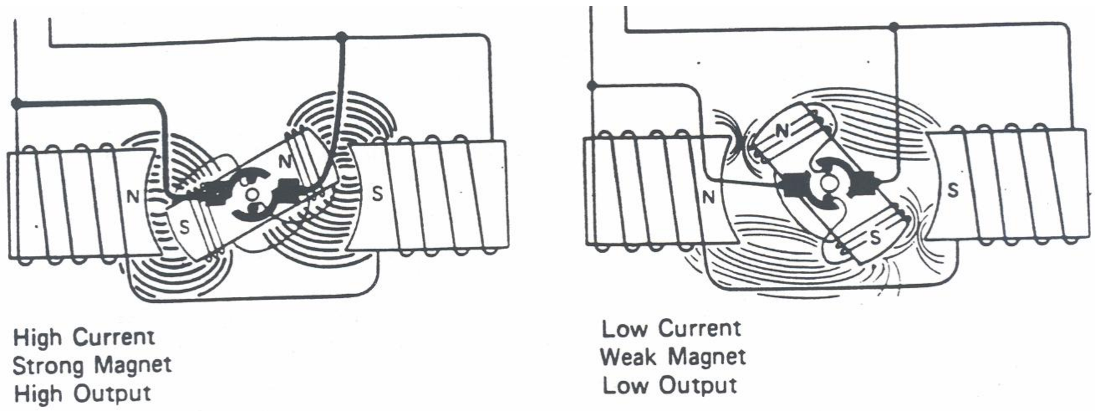


Figure 35

The brushes of a DC motor are made of either carbon or copper. Copper is a better conductor and wears longer. However, it is fairly hard and causes more wear on the motor commutator. Carbon brushes cause little commutator wear; however, they do chip and cause sparking, and they need to be replaced more often. Each brush usually has a wire (Pigtail) attached which is connected to the power supply.

The position of the brushes is very critical. If the voltage on the brush and the voltage of the commutator segment passing under the brush are not very nearly equal, sparking will occur. Changing position of the brush will help correct this defect. A worn commutator or broken brush will also cause sparking.

• •

DIRECT CURRENT GENERATOR

A direct current generator has the same parts as a direct current motor.

- Direct current from an outside source flows through the field coils.
- A power source, turbine, diesel or gasoline engine, or motor turns the armature.
- As the armature coils pass through the magnetic fields a voltage is generated in the coils. This causes current to flow in the coils.
- The current flows to the commutator and through the brush circuit to the machine, light or appliance where it will be used. (See Figure 36)

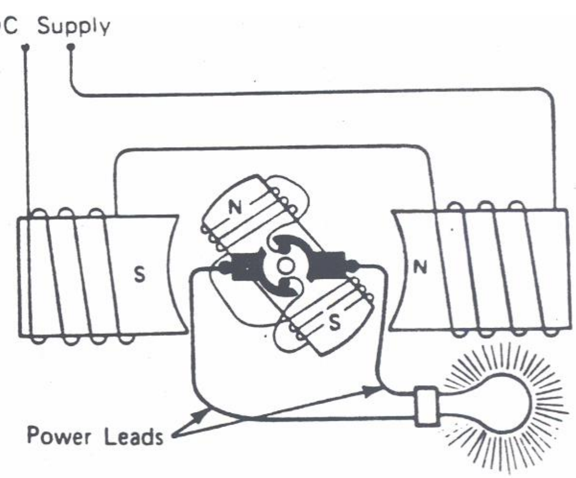
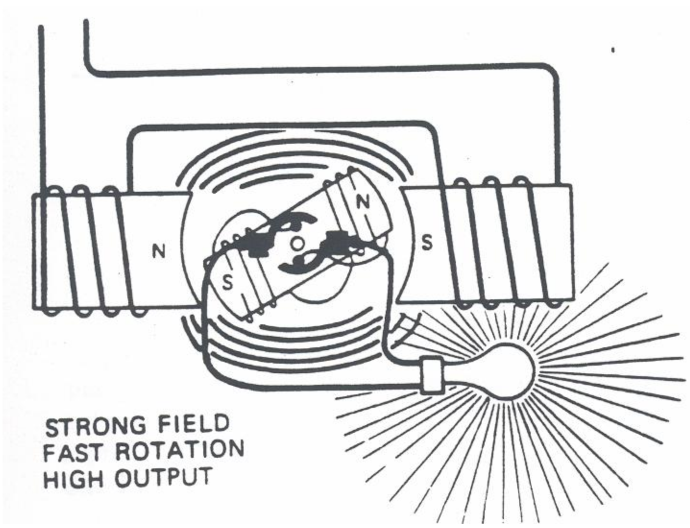
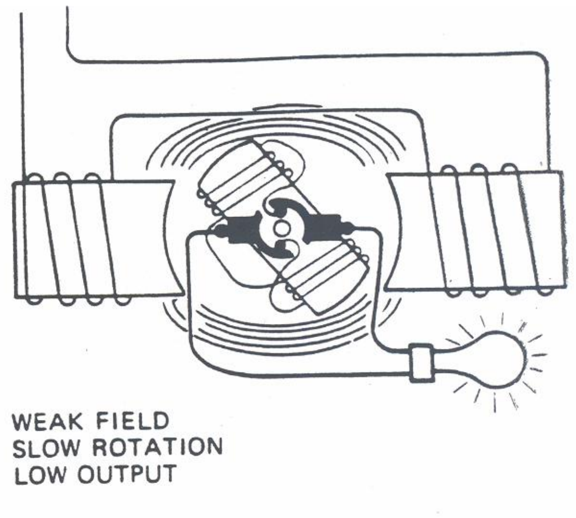


Figure 36

• Increasing the strength of the magnetic field and/or increasing the speed of the armature increases the generated voltage. 9See Figure 37)





• The voltage generated in the coils reverses itself each time that it passes a different pole. This would cause alternating current to flow. (See Figure 38)

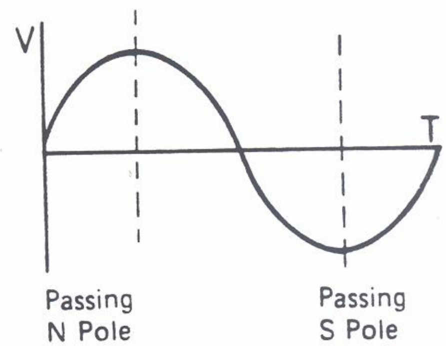


Figure 38

However, the commutator switches the end of the coils from one power lead to another as the voltage reverses itself. The switching keeps the voltage in the power leads going in the same direction. (See Figure 39)

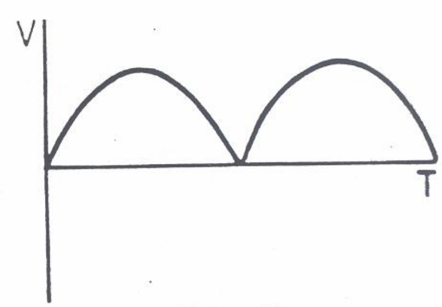


Figure 39

Industrial generators have many armature coils and the current flows into the power leads at peak voltage. The output has little more than a slight ripple. (Se Figure 40)

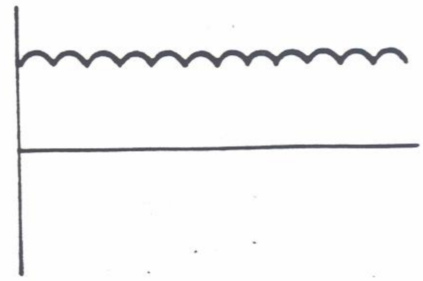


Figure 40

ALTERNATING CURRENT GENERATOR

In a direct current generator a magnetic field was created in the field coils and voltage was generated in the armature coils. (See Figure 41)

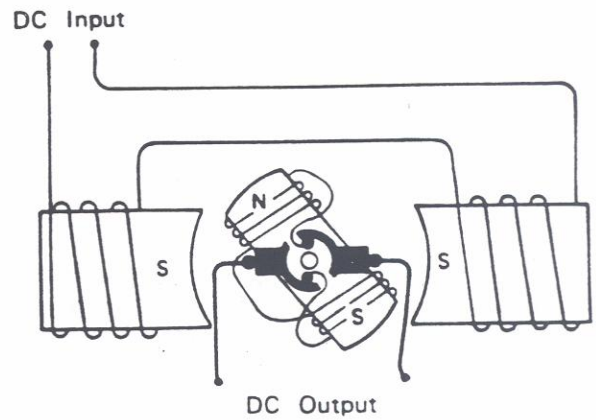


Figure 41

In an alternating current generator the magnetic field is created in the armature. DC current flows into the armature coils through slip rings. As the armature turns voltage is generated in the field coils. (See Figure 42)

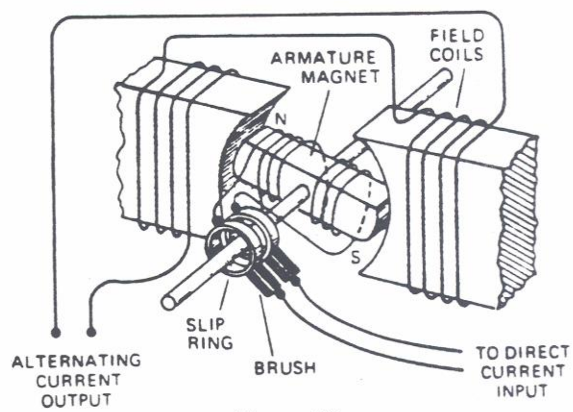


Figure 42

The output of a simple AC generator is shown in Figure 43.

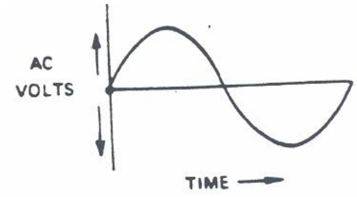


Figure 43

An industrial AC generator has 3 pairs of poles (See Figure 44). Each pair is independent of the other pairs. The output of each pair (Figure 44) is called a phase. The output of each phase is like Figure 43.

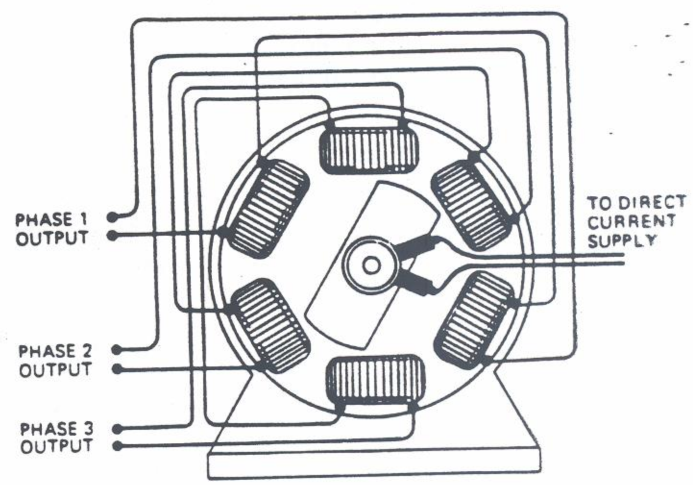


Figure 44

The output of the three phases looks like Figure 45.

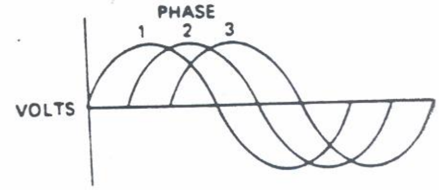


Figure 45

The stronger the magnetic field and the faster the armature rotation, the higher the voltage and current flow.

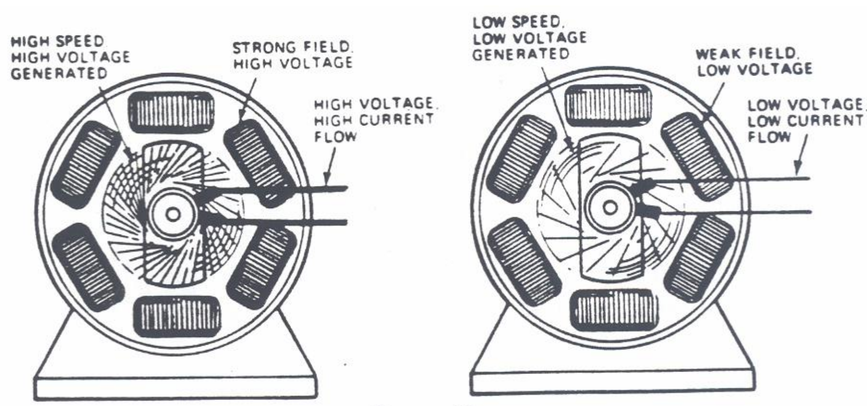


Figure 46

ALTERNATING CURRENT MOTOR

An alternating current motor has a frame and field coils that are just like those of an alternating current generator (See Figure 44).

The coils of a large alternating current motor would be connected to the corresponding coils of the generator.

The voltage in the generator coils will cause current to flow through the motor coils and create magnetic fields. The fields will change poles successively and create a rotating field inside the motor frame. (See Figures 47A through 47D)

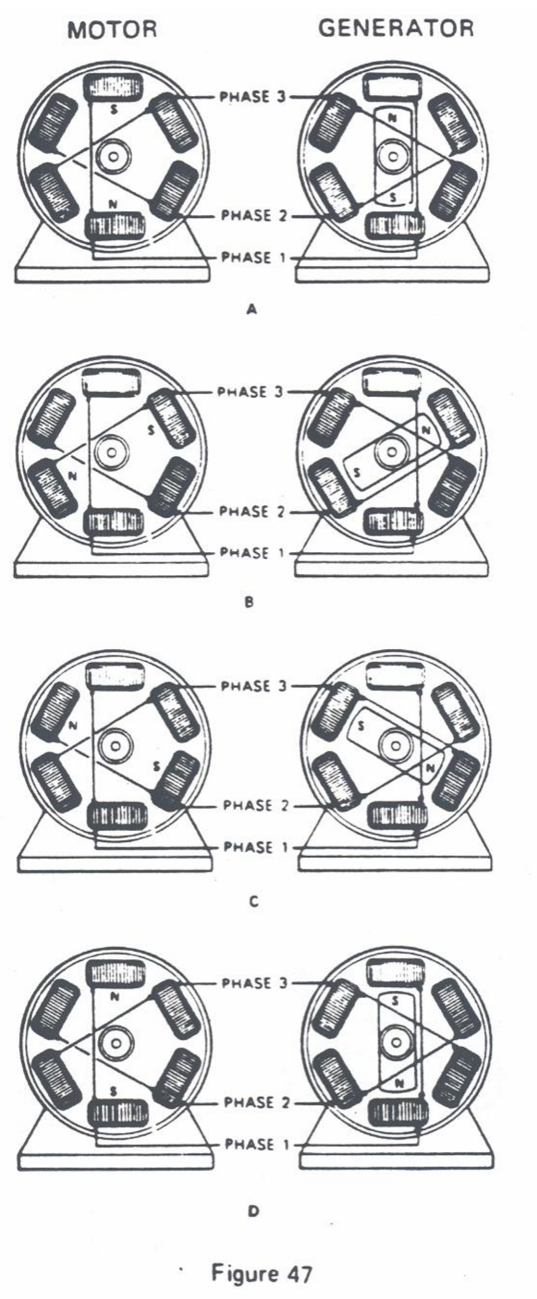


Figure 47

The armature of an alternating current motor is a core with a coil of wire. The ends of the coil are connected together. (See Figure 48)

As the motor field passes over the armature, a voltage is generated (or induced) in the armature coil, and current flows and creates a magnet. The magnet is attracted by the rotating field and rotates with it.

The voltage is induced in the armature coil only if the rotating field rotates faster than the armature does. The difference in armature rotation speed and field rotation speed is called Slip.

The more slip the more voltage is generated,and the stronger the armature magnet becomes. If the magnet is stronger, the motor rotates faster or with more force.

Slip	Armature Voltage Generated	Armature Current Flow	Armature magnet Strength	Power Output
High	High	High	High	High
Medium	Medium	Medium	Medium	Medium
Low	Low	Low	Low	Low

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HOIST MOTOR SPEED CONTROL

The speed of a mine hoist motor needs to be controlled. The speed of the alternating current motor, like the direct current motor, depends on armature current. In a mien hoist AC motor, armature resistances are placed in the armature, coil circuits. The resistances can be bypassed by closing switches. (See Figure 37)

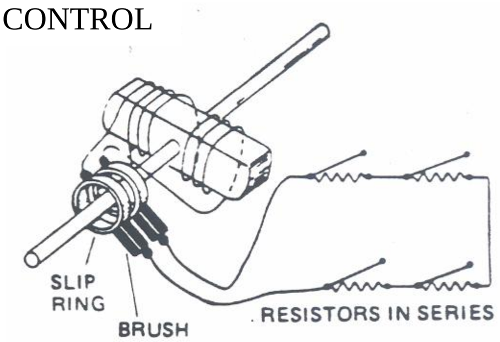

Figure 48

When starting the AC motor, all of the switches are open and the armature circuit has maximum resistance. At this time slip is at a maximum and the generated voltage is high. The high resistance keeps the armature current low. If the resistance were not tin the circuit, the armature current might get too high and damage the motor.

As the armature picks up speed, slip, the voltage and the current flow declines. The switches are closed, one by one, to allow additional current to flow through the armature coils. The armature continues to pick up speed until all of the switches are closed. The motor is then running at its best speed for the amount of work that it is doing.

To slow the armature the switches are opened one by one. This action:

- Increases the resistance of the armature circuit.
- Reduces the flow of current through the armature coils.
- Reduces the strength of the armature magnets.
- Causes the armature to slow down.

In a mien hoist the resistances are normally located in the hoist control room. The switches are in the hoist motor control box and are opened or closed by turning the motor controller. The switches and resistances are connected to the armature coils through slip rings and brushes.

Note that if we exchange the connections of two phases of the motor with two phases of the generator, the direction of rotation of the magnetic field will be reversed. This is how an AC motor is reversed.

STARTING DIRECT CURRENT MOTORS

When the armature of a DC motor is turning, a voltage is generated in the armature coil as the coil passes through the motor's magnetic field. This voltage opposes the voltage from the power supply. The voltage causing current to flow in the armature coils is equal to the difference between the power supply voltage and that being generated in the armature coils.

When the armature is not turning all of the power supply voltage is causing current to flow. If the power supply voltage is too high, too much current will flow. Therefore, the voltage first applied to the armature should be low. It is increased slowly as the motor picks up speed and begins to generate the opposing voltage.

The motor is at full speed when the power supply voltage is at its maximum.

If the voltage to a running DC motor drops, the armature may slow down and stop. In this condition, there may be enough voltage remaining to force enough current through the armature to burn the armature coils.

The voltage to the armature in a mine hoist motor is increased or decreased by strengthening or weakening the magnetic field of the DC generator, or by changing the output voltage of the rectifier.

Types of Direct Current Motors

A Shunt motor is show in Figure 49.

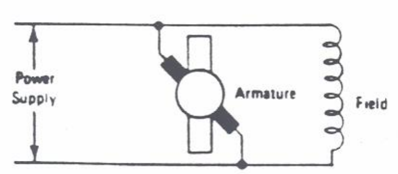

Figure 49

The field coil and armature (through the brushes) are both connected across the power supply. They are in parallel.

A Series motor is shown in Figure 50.

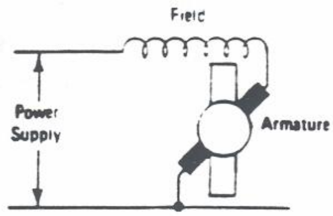

Figure 50

One terminal of the field coil is connected to one terminal of the armature. The two are then connected across the power supply. The armature and field coils are in series.

A Compound motor is shown in Figure 51.

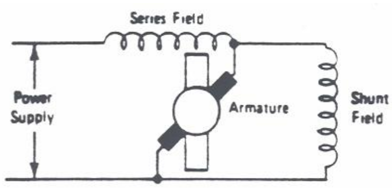

Figure 51

The motor has two fields, a shunt field and a series field. If the connections of the series field in a compound motor becomes reversed, as the motor starts it will rotate in one direction. As the armature current and the series field current increases, the series field will overpower the shunt field and cause the motor to reverse itself.

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HOIST OPERATION

Figure 52 shows a sample sketch of a mine hoist electrical system with an alternating current motor. It functions as follows:

- Alternating current power comes form the power company to the switch board and through the hoist power switch to the hoist control.
- The hoist control hoes two things:
  - It sends power to the alternating current motor fields, and
  - It controls the amount of resistance in the circuit that includes the armature coils and the resistor sets.
- When the hoist motor starts there is a high resistance in the armature and resistor circuit. The resistance is lowered as the motor picks up speed.

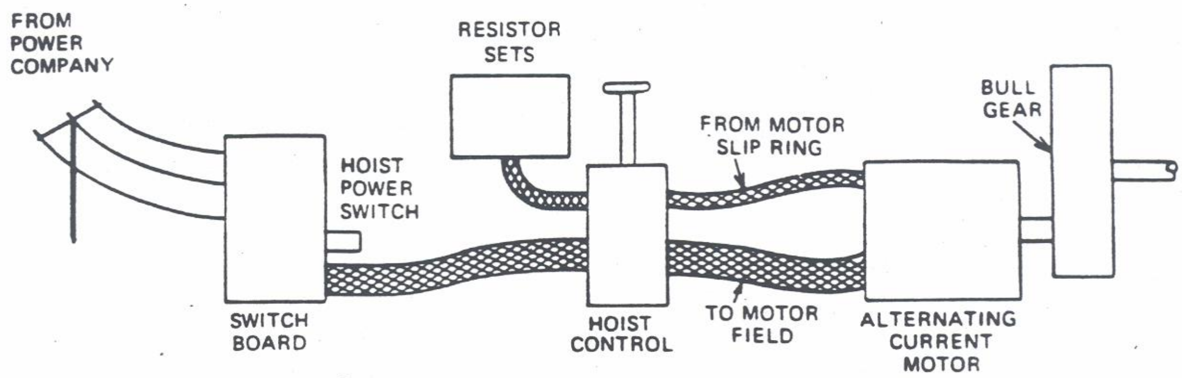

Figure 52

Figure 53 is a simple sketch of a mine hoist electrical system with a direct current hoist motor and a motor generator set. It functions as follows:

- Alternating current power from the power company goes to the switchboard and through the hoist power switch to the alternating current motor of the motor generator set.
- The alternating current motor drives the direct current generator and the exciter generator.

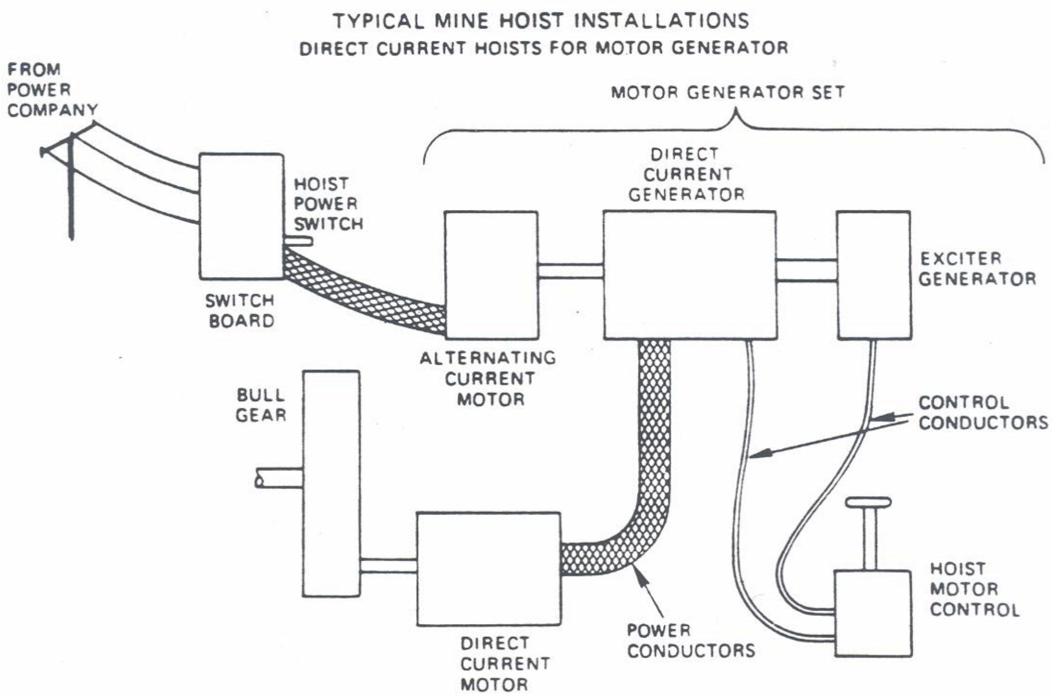

Figure 53

• The exciter generator is a small direct current generator that provides the current for the main generator magnetic fields.
• The output of the exciter generator goes to the hoist motor control then to the direct current generator fields.
• The hoist motor control is a switch that controls the direction and the amount of current that goes to the generator fields.
• The condition of the DC generator fields will determine the direction and amount of current that will be delivered to the hoist motor.
• The output of the main generator drives the hoist motor.

Figure 54 shows a simple sketch of a mine hoist electrical system with a direct current motor and a rectifier power supply. It functions as follows:

• Alternating current power goes through the switchboard to the hoist power switch, then to the rectifier.
• The rectifier changes the alternating current to direct current.
• The hoist motor control causes the rectifier to send current at the required voltage and in the proper direction to the hoist motor.

DIRECT CURRENT HOIST MOTOR RECTIFIER POWER SUPPLY

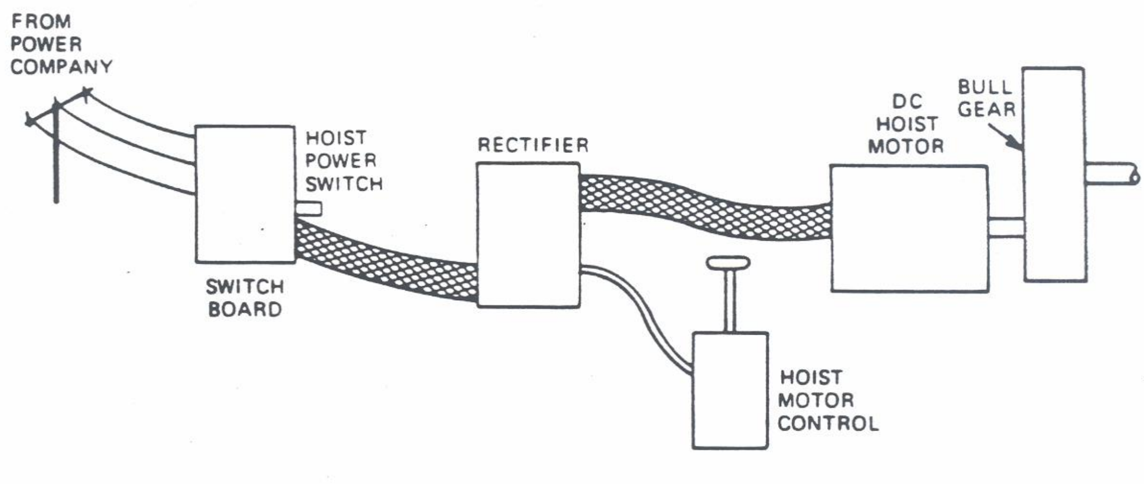

Figure 54

USING THE MOTOR AS A BRAKE

An electric motor may be used as a brake to control the speed of the machine that it drives. This feature may be used in a mine hoist, for example, to slow the conveyance when lowering a heavy load and when approaching the designated landing.

In a direct current motor the armature voltage is reduced below that of the opposing voltage being generated in the motor armature. The overall voltage then is forcing current to flow out of the motor armature rather than into it. In effect, the motor is now a generator. The energy required to generate the current acts as a brake on the motor armature and causes it to slow. The current that flows back can be sent back to the power company through the motor generator.

in some alternating current motors the motor is simply reversed. When lowering, for example, the hoist motor control is placed in the hoist position. The rotating field starts to rotate in the opposite direction and will slow the rotation speed of the armature.

In other alternating current motors, a switch is provided to substitute direct current for alternating current in one or two of the phases. Voltage is then generated in the armature coils as they rotate in the newly created magnetic field. The voltage is absorbed in the starting resistances. The energy thus absorbed acts as a brake on the motor armature.

The use of the motor as a brake is sometimes referred to as <u>Dynamic Braking</u>.

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TRANSFORMERS

The relationships between electricity and magnetism are used in another electrical machine called a "transformer." The transformer changes the voltage of alternating current. If it raises the voltage it is a stop-up transformer. If it lowers the voltage it is a step-down transformer.

You might ask "Why do we want to change the voltage?" We want to change voltage because for some applications high voltage is preferred and for others, low voltage. For example, transmission losses are lower if electric power is transmitted at high voltage and low current (we covered that in a previous section). However, at the point where electricity is used, that is, generated and/or handled, this high voltage is more dangerous than low voltage. (Remember that voltage is the pressure causing current to flow.) High pressure/voltage may cause current to flow in places where it is not wanted, such as between poorly insulated conductors or from conductors to the machinery frame. High voltage may also cause sparking on motor commutators. It may also be a source of fire or damage to motors, heaters, lights, controls and other equipment. Therefore, it is safer and more economical to have low voltage where the power is generated and used, and to have high voltage where power is transmitted.

Here is what the inside of a transformer looks like. (Figure 55)

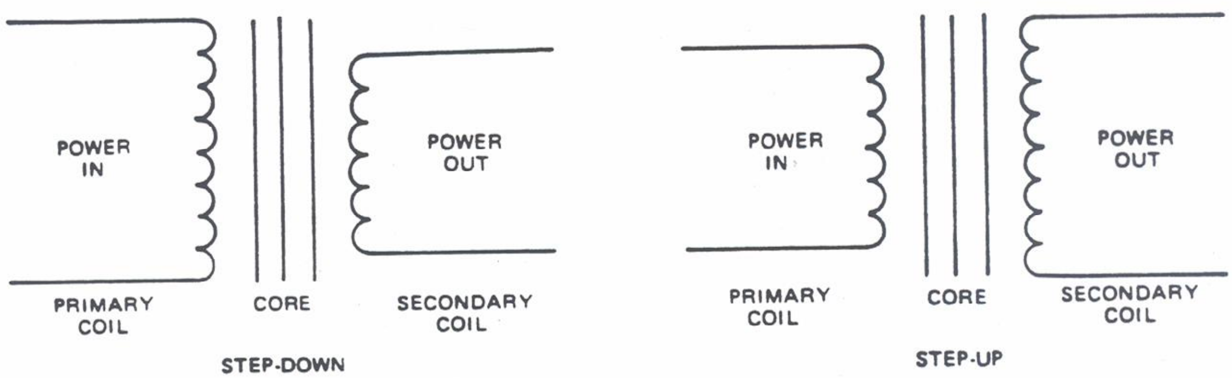

Figure 55

A transformer consists of two coils with a common core. Alternating current flows into the primary coil in one direction and makes a magnet out of the core. The build up of magnetism in the core causes a voltage to be generated in the secondary coil. As the current reverses itself in the primary coil, the magnet is reversed and causes a reverse voltage to be generated in the secondary coil. Thus, the alternating current flowing into the primary coil generates a voltage which causes current to flow in the secondary coil.

Since power losses in a transformer are very small, for the purpose of this explanation e will consider them to be zero, the power flowing into the primary coil (Pp) is equal to the power flowing out of the secondary coil (Ps).

The voltage going into the primary coil (Ep) and the voltage going out of the secondary coil (Es) are proportional to the number of turns of wire in each coil (Np for the primary and Ns for the secondary). Suppose we have a transformer like this one, Figure 56.

Primary

Pp - Power = 1000 Watts
Np - Turns = 100
Ep - Volts = 100
Ip - Amperes = ?

Secondary

Ps - Power = ?
Ns - Turns = 10
Es - Volts = ?
Is - Amperes = ?

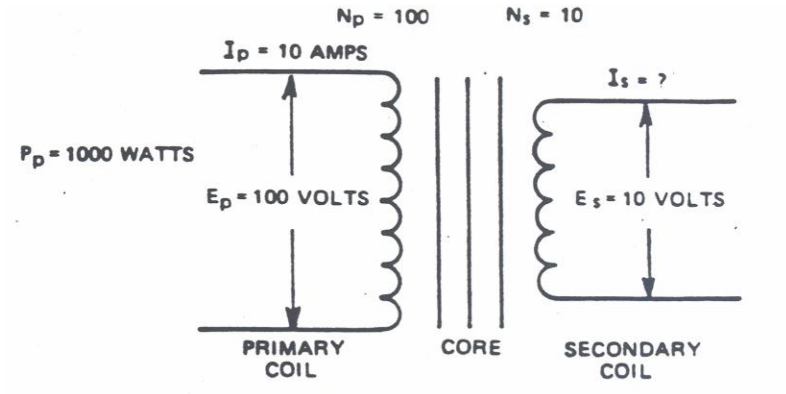

Figure 56

Since we know the power and volts into the primary, and the number of turns in both the primary (Np) and secondary (s), we can solve for the unknown values. For example, Primary current (Ip):

1000 watts going into the primary at 100 volts;

Pp = Ep X Ip; Pp = 1000; Ep = 100

Then; $Ip = \frac{Pp}{Ep} = \frac{1000}{100} = 10$

Secondary Power (Ps)

Since there are 1000 watts of power going into the primary Pp, there must be approximately 1000 watts of power from the secondary Ps.

Secondary Voltage (Es) Pp = Ps; Ps = 1000 watts

Since there are 100 volts and 100 turns in the primary Ep and Np, and 10 turns in the secondary Ns.

$\frac{/ep}{Np} = \frac{Es}{Ns}$ or

$\frac{100}{100} = \frac{Es}{10}$ or $Es = \frac{100}{100} \times 10 = 10$ volts.

Secondary current (Is)

Since there are 1000 watts of power in the primary (Pp), there are also (for our purpose) 1000 watts in the secondary (Ps).

Pp = Ps = 1000 watts.

Also $Ps = Es \times Is$ or

$1000 = 10 \times Is$ or

$$Is - \frac{1000}{10} = 100 \text{ amperes.}$$

In summary then, remember these relationships about transformers

$Pp = Ps$ (approximately)

Therefore: $Ep \times Ip = Es \times Is$

$$\frac{Ep}{Np} = \frac{Es}{Ns}$$

Use of Laminations

The magnetizing and demagnetizing that occur in transformers, motors and generators cause stray currents, called eddy currents, to flow through the magnet itself. The power that is used by this current flow ($I^2 \times R$) comes from the power supply and is a loss.

In order to reduce these losses to a minimum the cores for electric motor and generators and for transformers are not made of solid iron. Instead they are made of thin, soft iron plates (laminations), stacked together and insulated from each other, usually by insulating varnish (See Figure 57). The laminated construction reduces the flow of the eddy currents.

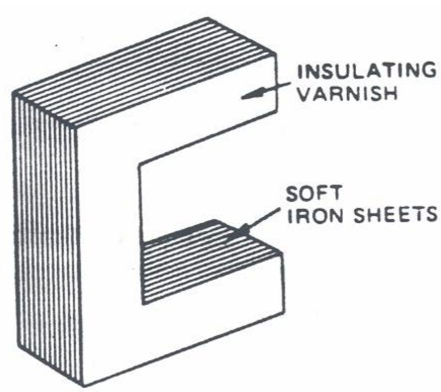

Figure 57

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ELECTRICAL SAFETY

Electricity can be dangerous if not properly controlled.

If electrical machinery is used near flammable materials, vapors, or gases, sparks may be given off and cause a fire.

If the current flowing through a conductor is greater than the conductor can carry safely, the conductor may overheat and cause a fire or otherwise damage the machines.

If just 1/10 of an ampere passes through your body the shock could kill you.

Federal safety regulations require that steps be taken to prevent such accidents. Basic requirements are as follows:

> Electrical machinery that is used in mines and other areas where flammable dust, gas, or vapors may be present must be enclosed. This will prevent sparks, such as occur on motor commutators, switches, and at loose connections, from igniting the flammable materials.
>
> Every electrical circuit must use conductors that are large enough to carry the normal current flow of the circuit, plus an acceptable overload without overheating. For most circuits a 25% overload is allowed. The interrupt the current flow if the normal load plus the overload is exceeded.

OVER CURRENT PROTECTION

Electrical equipment and conductors can only carry a limited amount of current without being damaged. Fuses or circuit breakers prevent too much current from flowing through the conductors or through the equipment.

FUSE

A fuse is a piece of metal that is placed in the circuit, in series with the load. When too many amperes flow through the fuse the heat generated (I^2 X R) cases the metal to melt and breaks the circuit. A new fuse must be installed to restore power.

CIRCUIT BREAKER.

A circuit breaker is a magnetic switch that is also placed in the circuit, in series with the load. When too much current flows through the conductors, the magnetic switch opens and stops the flow. The circuit breaker may then be reset, that is, the switch closed and the circuit re-energized..

Conductors supplying power to a mine or other facility are protected by circuit breakers of ruses, before they enter the mine. In addition, a very large fuse or circuit breaker (lightning arrester) is installed to break the circuit if lightning strikes the power lines. A ground wire is also provided to lead the lightning to ground.

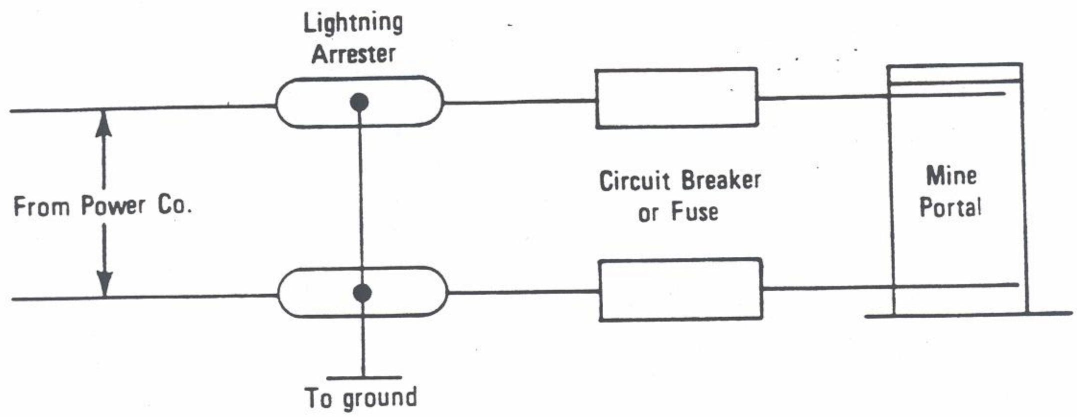


Figure 58

ELECTROLYSIS

When an electric current flows through a mixture of water and dissolved metallic compounds, that is, iron oxide (rust). Corroded metal, clay, etch, chemical changes take place. Oxygen and hydrogen may be generated, and metals with which the current comes in contact may be eroded away and deposited elsewhere. This action can severely damage metal structures that are in contact with the moist material. Good grounding of all equipment can help to keep the voltage difference between the structures to a minimum and reduce the possibility of damage. (See Figure 59)

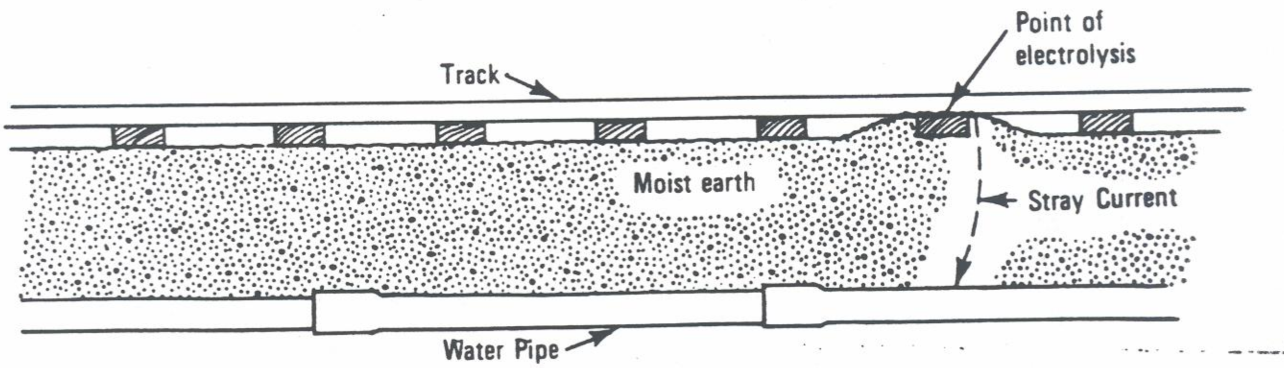


Figure 59

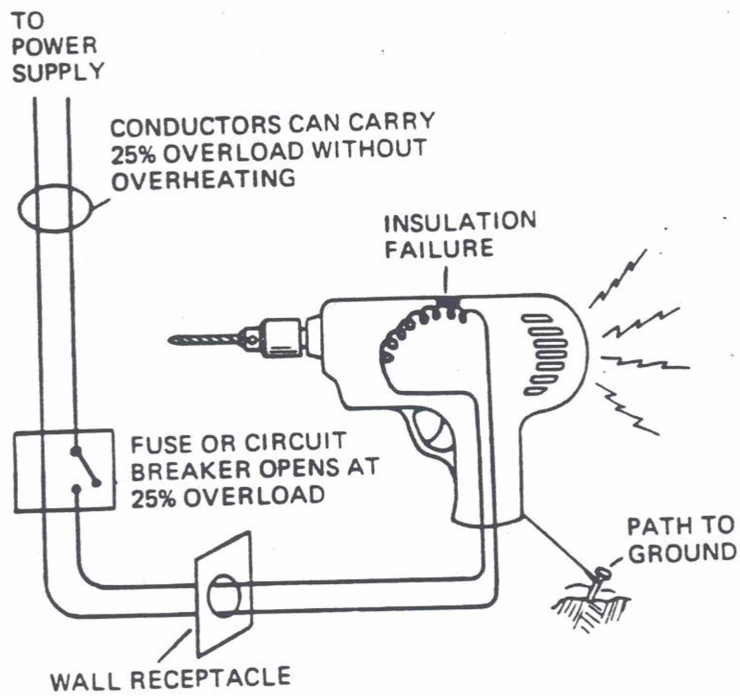


Figure 60

Conductors and other current-carrying parts of the machines shall be insulated or enclosed to prevent persons from touching them. In addition, some areas restrict the maximum voltage permitted on exposed conductors such as trolley wires. Illinois restricts the voltage to 275 volts.

Exposed metal parts of electrical machinery that do not carry current normally, the frames, strands, enclosures, must be connected to the ground. Normally, the conductors and parts of electrical machines through which the current flows are insulated from the frames and other structural parts of the machines. If the insulation is damaged these parts may carry current. If a person touches one of the current carrying parts, his/her body will provide a path for the current to flow to the ground. The person will receive a shock and may be killed. The ground connection provides a path of current to flow to the ground. Thus, if a break occurs in the insulation, current will flow to ground in sufficient quantity to open the overcurrent protection device.

DE-ENERGIZING EQUIPMENT

Prior to having personnel work on electrical equipment, the power shall be cut off from that equipment and measures taken to prevent its being turned back on until the work is completed. A typical measure is to lock the switch box closed, hang an sign on the box stating, DO NOT CLOSE SWITCH, and give the key to the person working on the equipment.

Unit 21

HOIST INSPECTION

Periodic inspections of the hoist, shaft and related parts are made to assure that operations can be conducted safely. This unit outlines basic inspection requirements. You will learn detailed requirements from your mine's rules and regulations.

The hoist operator must know:

1. Hoist parts that require inspection;
2. How often these parts require inspection;
3. Conditions which indicate maintenance or attention is required;
4. Method of recording information in log.

<u>At the beginning of each shift</u>

The hoist operator examines the hoist and tests overtravel, overspeed, deadman controls, position indicators, and breaking mechanisms. This includes:

- visually checking
  - ✓ wiring for loose connections, damaged insulation
  - ✓ hoist housing, structure and drum for loose bolts, cracks and similar defects
  - ✓ brake mechanism for loose/worn shoes, mechanical defects, hydraulic pressure
  - ✓ safety cable for lubrication, broken wires, deformation
  - ✓ conveyance for loose, missing or broken parts
  - ✓ safety dogs
- operating hoist full length of the shaft to make sure that
  - ✓ shaft is clear and will accommodate skip/cage
  - ✓ appearance and sound of running hoist is normal
  - ✓ wire rope has no apparent defects
  - ✓ depth indicator, ammeter, rope speed meter, and other functioning properly
  - ✓ brakes, clutches and other components are normal
- test the following
  - ✓ communication systems
  - ✓ overspeed controls
  - ✓ overwind controls
  - ✓ slack rope cut-off

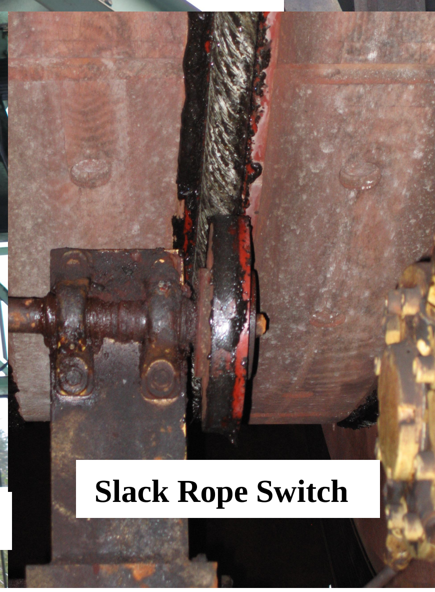
<u>Daily – Visually Examine</u>

- Rope and conveyance – connections to conveyances and drum should be checked.
- The hoist operator should look for abnormalities in the ripe, including:
  - ✓ reduction in rope diameter
  - ✓ stretching of the rope
  - ✓ worn, broken or corroded wires
  - ✓ indications of mechanical abuse
  - ✓ abrasions
- Safety catches
- Sheaves
- Shaft (coal)

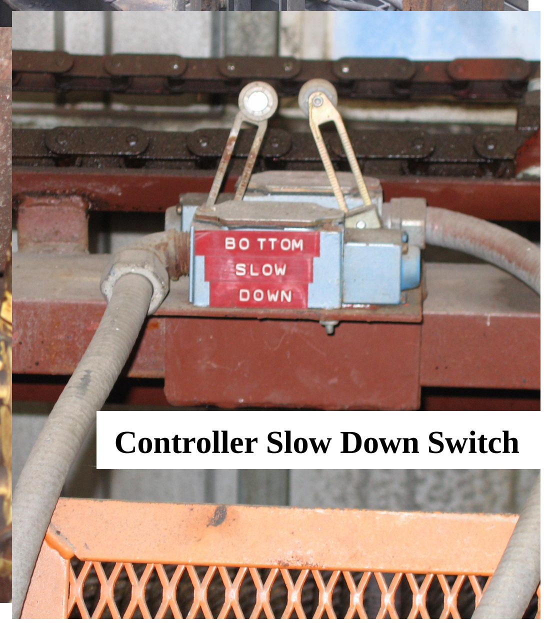
Shaft Over travel Switch

Magnetic Stop Switch

Over Travel Switch



Slack Rope Switch



Controller Slow Down Switch

Controller Over Travel

Unit 22

MAINTENANCE

Maintenance is the work that is done to keep the mine host and its parts repaired and in safe operating condition..

Maintenance includes:

- housekeeping
- inspection
- lubrication
- repairs
- replacement of parts
- adjustments

There are two kinds of maintenance:

- corrective maintenance, which is repairing or replacing parts that have broken down
- preventive maintenance, which is repairing, adjusting, or replacing parts before they break down.

This work may be the responsibility of the hoist operator or the maintenance personnel. In either case the hoist operator must have a systematic procedure and adequate records to assure that the required work is done according to regulations.

Maintenance instructions come from several sources:

- federal, state or local regulations
- maintenance manuals put out by the manufacturers of the hoist, hydraulic systems, and other systems
- maintenance procedures put out by the mine foreman, maintenance foreman and other mine managers.

The hoist operator should know the maintenance procedures required to be performed

- pre-shift
- post-shift
- daily
- weekly
- monthly
- annually

and the person responsible for doing each.

He/she should have a record of when each task was performed and who performed it.

A check-off list with the above information is a must for a good maintenance

Hoistmen shall be informed when men are working in a compartment affected by that hoisting operation and “Men Working in Shaft” sign shall be posted at the hoist.

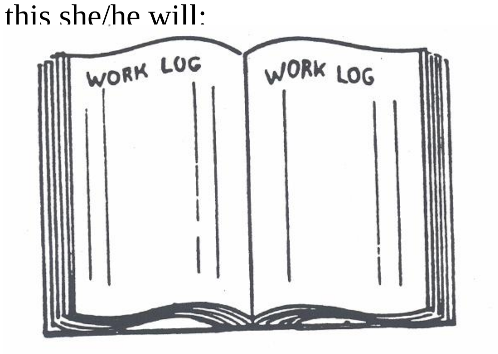
When men are working in a shaft “Men Working in Shaft” signs shall be posted at all devices controlling hoisting operations that may endanger such men.

Beginning of Shift Activities

At the beginning of a shift, the hoist operator has five basic tasks to perform to assure that the hoist is ready to operate:

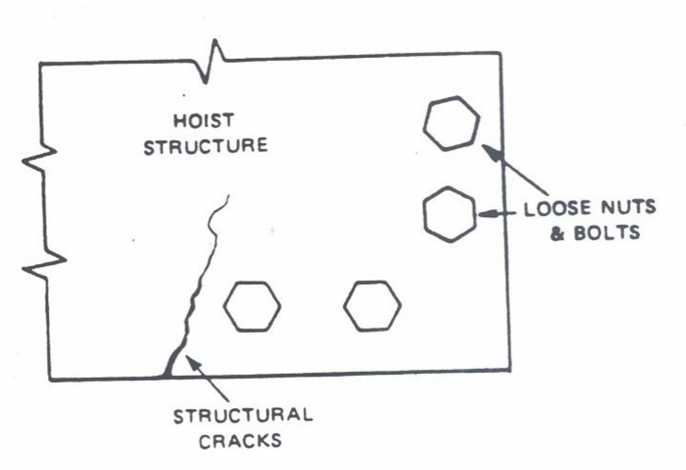
1. Check the general condition of the hoist
2. Check the hoist parts for proper lubrication
3. Check the power supply to the hoist
4. Operate the hoist the full length of travel
5. Check the operation of the safety devices

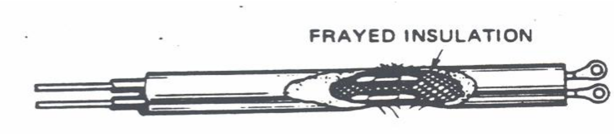
The first task the host operator does is to find out the general condition of the hoist. To do this she/he will:

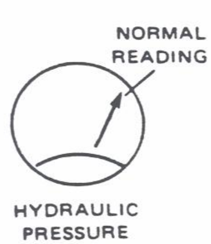


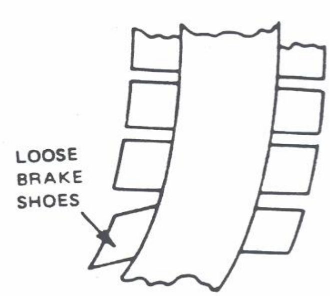
- Find out what happened to the previous shift:
  - Read log
  - Talk to previous operator

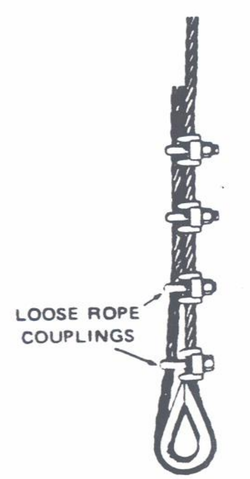
- Visually inspect for defects, such as:
  - Hoist anchorage, structure, and drum: loose bolts and nuts, structural cracks
  - Brakes: abnormal hydraulic or pneumatic pressure, loose shoes or worn bands
  - Wiring: frayed, insulation, loose connections
  - Hoist rope: loose couplings on conveyance and safety cables, no slack in safety cable, needs lubrication.









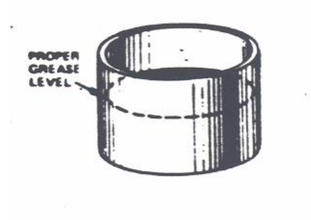


The next task a hoist operator does when he/she comes on shift is to assure that lubrication is provided to the points that require it:

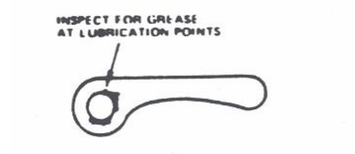
In I-A-13 various lubrication systems were described. Here is how the hoist operator will use them to assure that the hoist is properly lubricated.

For installed grease systems, he/she will:

- Inspect grease supply in reservoir



- Test the system operation

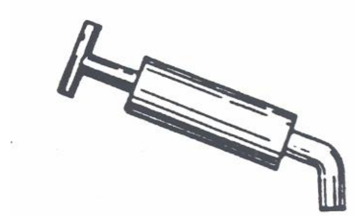


- Inspect for grease at the lubrication points
- Request assistance if necessary

Record activities in the log.

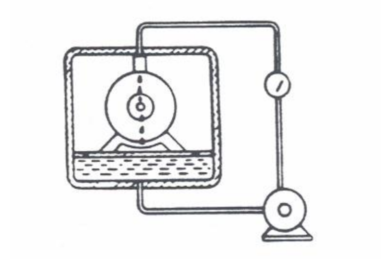
With a portable grease gun the hoist operator will:

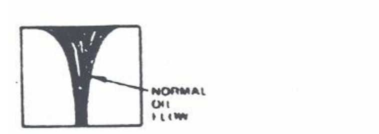
- Inspect for grease at points to be lubricated
- Lubricate where necessary.

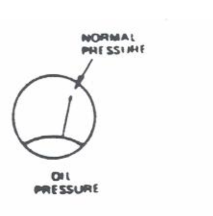


For a hoist with an oil flow system he/she will:

- Inspect oil supply in reservoir
- Inspect pump (look at pressure gauge)
- Inspect for leaks
- Inspect sight glass for normal oil flow
- Request assistance if necessary



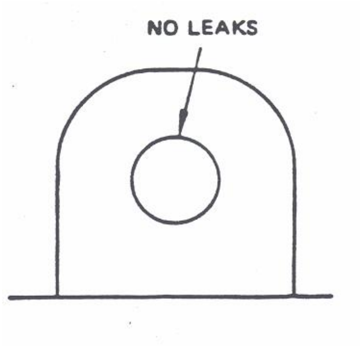


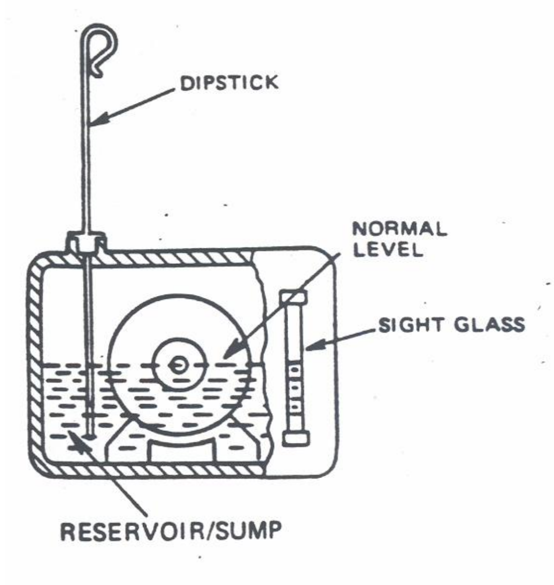


Record activities in the log.

For hoists with an oil reservoir system he/she will:

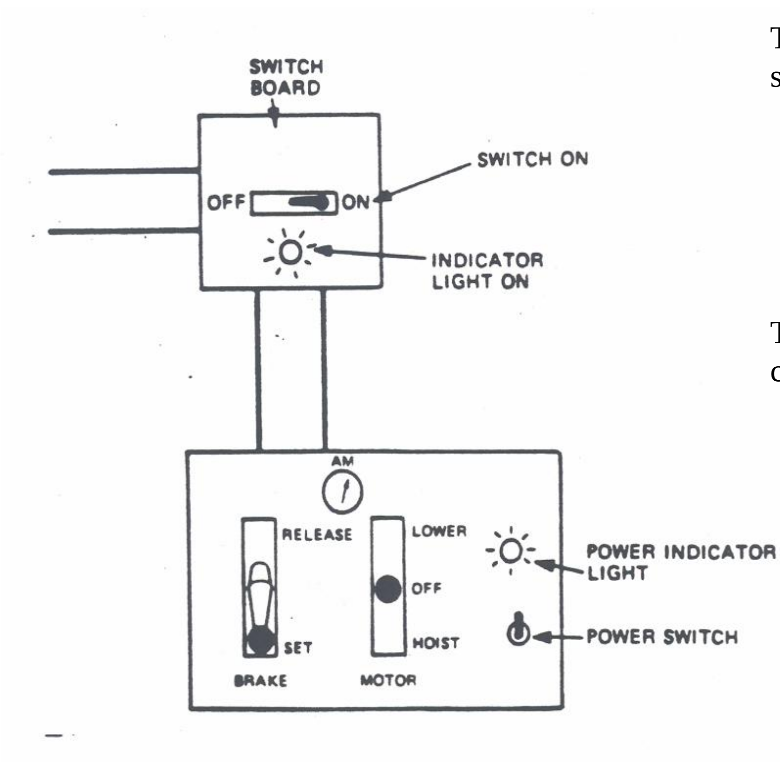
- Inspect oil supply in reservoir
- Inspect bearings for leaks
- Request assistance if necessary





Record activities in the log.

The third task the hoist operator performs is to assure that power is available to all parts of the hoist. The power is controlled by switches. If the switch is **CLOSED**, power flows through the switch and is **ON**. If the switch is **OPEN**, power cannot flow through the switch and is **OFF**.



Record activities in the log.

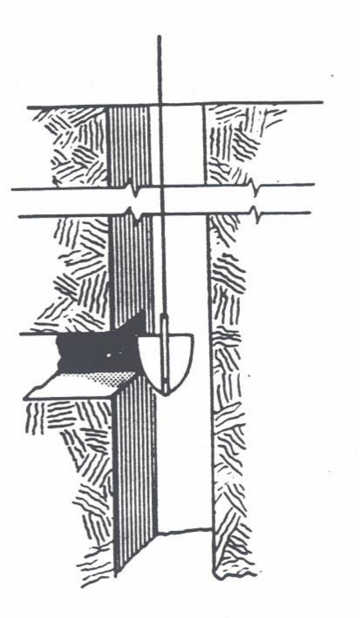
To assure that power is available to the switchboard the hoist operator will:

- Close the main power switch on the switchboard (turn power **ON**.)
- Note if the indicator light is **ON**.

To assure that power is available to the hoist control stand:

- Close the power switch on the control stand (turn power **ON**.)
- Move the motor control in one direction.
  - Note deflection of ammeter
- Move the motor control in the other direction.
  - Note deflection of ammeter
- Request assistance if test fails.

The next task the hoist operator does is to run an empty conveyance at slow speed the full length of the shaft. This is done to assure that the shaft is clear and that the controls operate properly. Often an inspector rides in the skip or cage and he/she looks for abnormalities in the shaft. The specific procedure for operating the hoist is in the unit “Routine Shift Activities.”

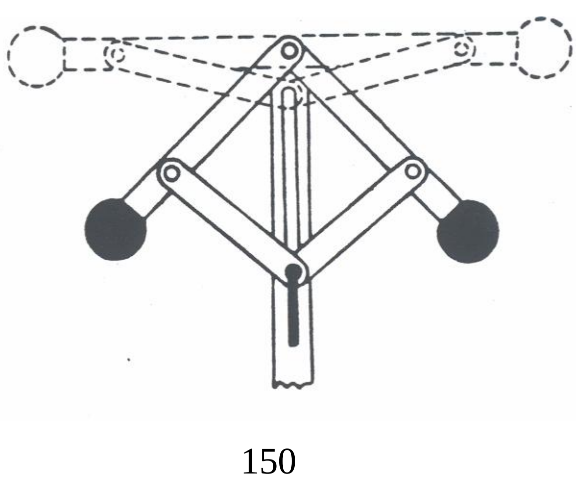


Another task to be performed at the beginning of the shift is to test the hoist safety devices. If a device fails its test, it must be repaired before starting operations. The results of these tests must be recorded in the log. These tests may be performed by the hoist operator or by maintenance personnel.

Overspeed Cutout Switch

The overspeed cutout switch is built into the Lilly, Simplex or other safety controller. To test the functioning of this device:

- Set the brake and stop the hoist
- Manually raise the weights on the governor
- Check to see that the main power switch opens (power turns **OFF**)
- Close the main power switch if is opens satisfactorily, otherwise have it repaired.

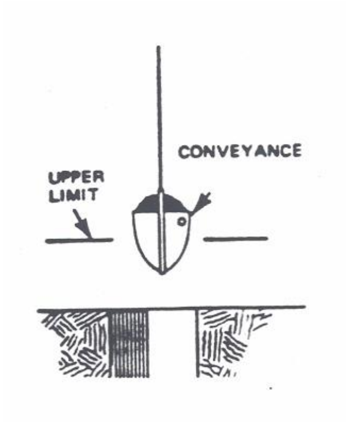


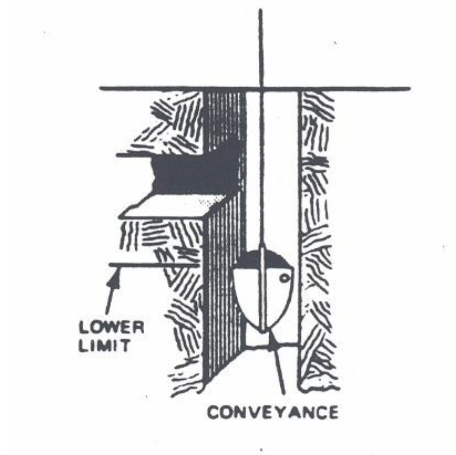
Overtravel Cutout Switch

There are two cutout or limit switches to prevent overtravel, one at each end of the shaft. The switch near the top prevents the conveyance from traveling too far above the collar; the switch near the bottom prevents travel too far below the deepest landing.

To test the cutouts, the hoist operator will:

- move the conveyance slowly above/below the collar/deepest landing. The main power switch should open and the brakes should be set as the conveyance crosses the cutout level.



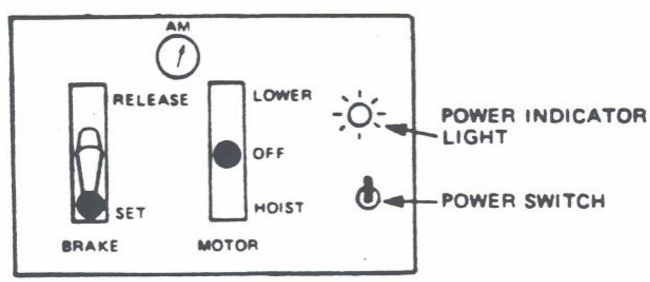


To test the cutouts, the hoist operator will:

- Set the brake and put the motor control on OFF
- Close the overtravel bypass switch
- Return the conveyance to the normal operating area.

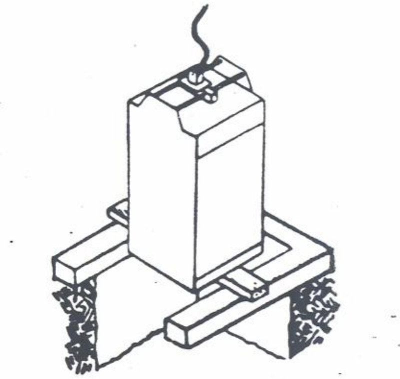
If the main power switch does not open, the hoist operator will:

- Set the brake
- Put the motor control on OFF
- Request assistance.



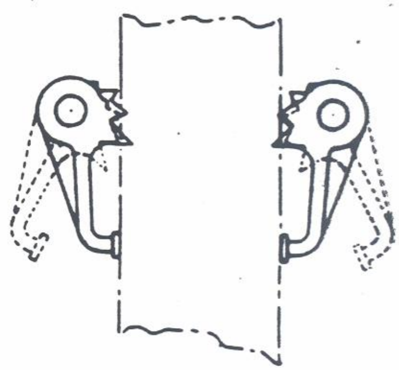
One some hoists, the safety controller also has an overtravel cutout switch. On such hoists the safety controller must be bypassed in order to test the shaft overtravel switches.

Slack Rope Switch and Conveyance Safety Dogs



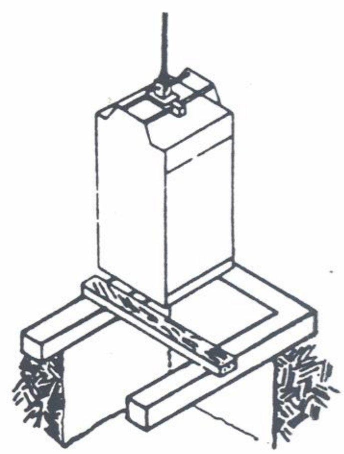
The slack rope switch will cut off power to the hoist and apply the drum brakes if the rope goes slack. To test the switch the hoist operator will:

- Support the conveyance. The support may be wood/metal beams or chains
- Slack the hoist rope



As the rope goes slack:

- The main power switch should open
- The safety dogs should begin to clamp on the shaft guide.

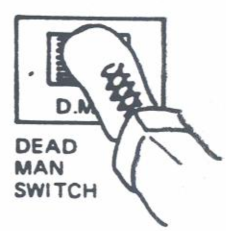


If the test is successful:

- Set brake
- Put motor control on **OFF**
- Close slack rope bypass switch
- Raise conveyance slowly until it is lifted off the supports if beams were used
- Remove the supports.

If test fails, request assistance

Deadman Switch



Most hoists are equipped with a "deadman switch." The switch is normally open and cuts off power to the hoist. The purpose of the switch is to remove power from the hoist and apply the brakes if something should happened to the hoist operator (has a heart attach, drops dead or becomes ill). The switch may be located on the floor or on the side of the hoist control stand. The operator closes the switch by standing on it, or by pressing his/her knee or leg against it.

To test the deadman switch, the operator tries to apply power to the hoist with the switch open. (He/she is not standing on it or pressing against it.) If power is applies, the switch is not working properly and must be repaired.

Each hoist is different. The above safety devices are required by law but there may be additional safety devices in your mine. You must learn what they are and how to test them. This will be done in Part II and III.

State regulations require that complete records be kept of installation, lubrication, inspection, tests, and maintenance of shafts and hoisting equipment. Your mine will have specific rules for making log entries in agreement with these regulations.

REFERENCE LISTING

Coal Mine Safety Laws of Virginia

Safety and Health Regulations for Coal Mining in Virginia

Title 30 Code of Federal Regulations (30 CFR)

Illinois Department of Natural Resources, Hoisting Manual